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Quartz Creek Landscape Assessment

Seward Ranger District, Chugach National Forest

QUARTZ CREEK LANDSCAPE ASSESSMENT

2010

Prepared by:

Team Leader	Chad Hermandorfer
Recreation	Courtney Brown
Geology and Minerals	Steve Hohensee
Heritage	Robert (Max) Dean
Hydrology	Bill MacFarlane
Soils	Dan Svoboda
Fire and Fuels	Todd Camm
Fisheries	Brian Bair
	Greg Robertson
Wildlife	Mary Ann Benoit
Botany/Weeds	Katherine Carsey
Vegetation/Ecology	Marcus Chin
GIS	Linda Kelly
Lands	Josh Milligan
Writer/Editor	Maple Taylor

Approved by: ______________________________ ______________

Travis Moseley, Date

Seward District Ranger

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1. Introduction

Purpose

A landscape assessment is a broad-level analysis to provide context and information regarding the effects and impacts that management decisions may have on the ecosystem. Its purpose is to guide land management decisions and provide a means of refining the desired conditions, management prescriptions, and standards and guidelines from the Chugach National Forest Land and Resource Management Plan (USDA Forest Service 2002a; or simply Forest Plan), and current policy and other applicable State and Federal regulations. A landscape assessment is an intermediate step between the Forest Plan and project planning, and serves as a basis for developing project-specific recommendations and determining restoration and monitoring needs within the analysis area.

The structure (including major sections) of this landscape assessment is based on "Ecosystem Analysis at the Watershed Scale: A Federal Guide for Watershed Analysis," a publication produced by a variety of agencies, governments, and organizations (Regional Interagency Executive Committee 1995). The analysis is driven by a set of issues and key questions for a specific watershed. This type of analysis is not a decision-making process, but uses existing data and information to establish the context for project-specific decisions. This document is divided into the following eight sections:

1. Introduction
2. Watershed Characterization
3. Key Issues and Questions
4. Current Conditions
5. Reference Conditions
6. Synthesis and Interpretation
7. Desired Condition, Opportunities, Management Strategies, Data Gaps, Monitoring and Research Needs
8. Recommendations

We discuss the following topics within each of these sections:

- Lands
- Geology, Minerals, and Soils
- Hydrology
- Vegetation and Ecology
- Botany and Weeds
- Fire and Fuels
- Aquatic Species and Habitats
- Terrestrial Species and Habitats
- Heritage
- Recreation

The Analysis Area

The Quartz Creek Watershed (or watershed), located on the Seward Ranger District of the Chugach National Forest (CNF), covers approximately 75,086 acres (117 square miles) on the eastern Kenai Peninsula. The watershed is about 45 miles southeast of Anchorage, Alaska, and about 30 miles north of Seward, Alaska (figure 1). The watershed lies within the Kenai Mountains, and Quartz Creek is one of the major tributaries of the upper Kenai River. The Seward and Sterling Highways provide access to much of the watershed, and the community of Cooper Landing is just to the west of the mouth of Quartz Creek.

The watershed is characterized by glacially sculpted valleys flowing south/southwest and draining into Kenai Lake. Much of the watershed is undeveloped backcountry, where activities are limited by the difficult access. The land adjacent to the Seward and Sterling Highways is more developed, and provides recreational opportunities for skiing, hiking, biking, hunting, fishing, and snow machining.

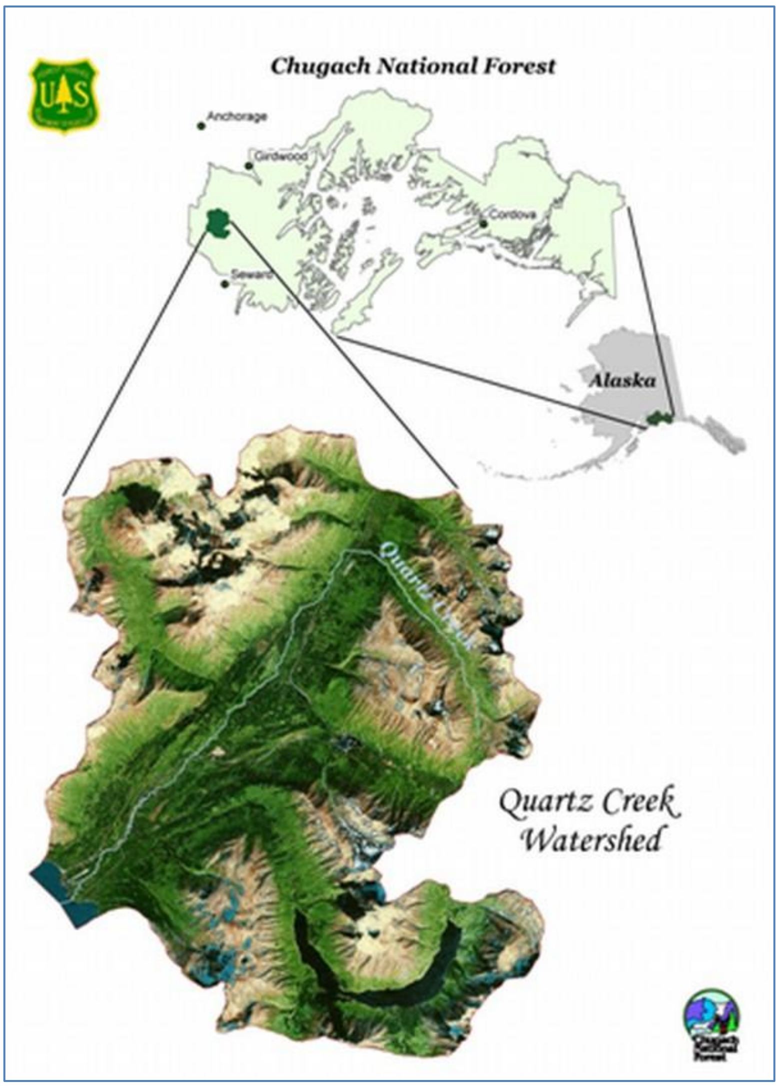

Figure 1. Location of the Quartz Creek Watershed

2. Watershed Characterization

Lands

With 94 percent of the land ownership, the Forest Service is the predominant landowner within the landscape assessment area; however, there are State of Alaska lands, Kenai Peninsula Borough lands, private property, and road and highway easements within or adjacent to these Forest Service System lands. In addition, there are two public land orders (PLOs) within the analysis area.

Figure 2. Land ownership within the vicinity of the Quartz Creek Watershed

Geology, Minerals, and Soils

Geology and Minerals

Geology. The predominant bedrock of the southern half of the analysis area is undivided sedimentary rocks of the Cretaceous Valdez Group, a thick sequence of deformed interbedded metasedimentary and metavolcanic rocks. This group is part of a belt of Cretaceous marine rocks 1,000 miles long and as much as 60 miles wide that extends along the Gulf of Alaska margin from Chatham Strait in southeastern Alaska to Kodiak and Shumagain Islands in southwestern Alaska. The Valdez Group is part of the Chugach Terrane. These rocks typically include sandstone, siltstone, argillite, slate, and phyllite. The entire sequence is folded and deformed and metamorphosed to grades ranging from zeolite to amphibolite facies.

Nelson et al. (1985) identified a lineament from air photos that may indicate the presence of a fault (Figure 3) in the Quartz Creek Landscape Assessment Area. This lineament has not been identified on the ground. The lineament trace is mapped from adjacent to Tern Lake south-southeast and crosses the western portion of Crescent Lake and continues south.

Valdez Group Types: Four late Cretaceous types occur in the analysis area. The most abundant unit is a thick sequence of sedimentary rock consisting of sandstone, siltstone, argillite, slate, phyllite, and rare beds of pebbly argillite (mapped in green as “Sedimentary rocks, undivided, Valdez Group” on the Geologic Map (Figure 3). Layers are generally a few inches to a few feet thick, but massive sandstone as much as several tens of feet thick are locally present. Valdez Group rocks are the sole bedrock in the analysis area.

Quaternary Deposits: This unit consists of undifferentiated, unconsolidated surficial deposits left by glacial melt water and alluvium from non-glacial streams (mapped in yellow as “Surficial deposits, undifferentiated” on the Geologic Map (Figure 3). They are recent deposits composed entirely of clastic material (clay, silt, sand, gravel, and talus). This unit occurs in valley floors and along river and creek bottoms primarily along the Seward and Sterling Highways and at the ends of Crescent Lake.

Minerals. Types of minerals administered by the Forest Service within the assessment area include locatable minerals (36 CFR 228, subpart A), salable minerals (38 CFR 226, subpart C), and leasable minerals (36 CFR 228, subpart E).

Locatable minerals claimants and operators have a statutory right to develop the mineral resource under the 1872 Mining Law. Locatable minerals typically include placer gold mining in the streams, but can also occur on the benches. The public approaches the Forest with a plan of operation prior to ground-disturbing activities. Salable minerals include sand, gravel, and rock. All of the valley floors in the assessment area are sands and gravels with potential for this type of use as needed. The disposal of salable minerals is a discretionary action. The Forest Service may determine whether to offer mineral material sales and administer disposal under the salable regulations cited above. A leasable mineral would be coal or gas; however, the assessment area does not provide favorable conditions for this type of use.

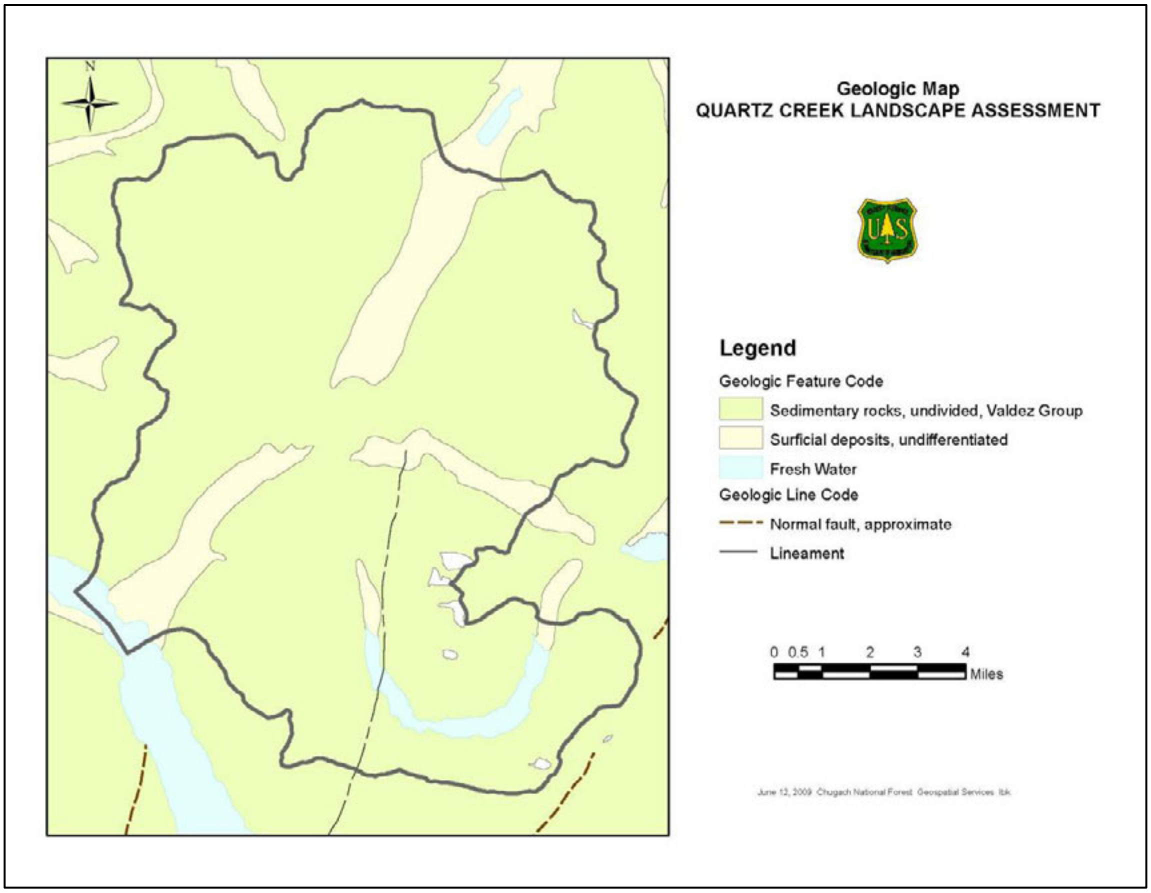

Figure 3. Geologic map of the Quartz Creek Landscape Assessment Area

Soils

Geomorphic Process

General Landscape History of the Kenai Peninsula. The CNF is dominated by mountains consisting of marine rocks that were uplifted starting in the late Cretaceous Period about 75 million years ago. The most obvious evidence of the uplift is the Eagle River Fault which separates the Kenai Mountains from the lowlands to the west. More recently, numerous igneous intrusions were exposed either through erosion of the overlying rock, or they were pushed up through the overlying rock.

Climate is probably the major contributing factor for the large variation in topography and ecosystems that occur in south-central Alaska. The CNF, as part of the coastal region of the north coast of the Gulf of Alaska, receives the vast majority of its weather from the Gulf of Alaska. Storms pick up moisture from the waters warmed by the Japanese Current and move over the land, rising orographically over the high mountains causing increasing amounts of precipitation as the elevation increases. The mountains form a barrier to not only the precipitation, but also to the moderating influence of maritime temperatures. The landward side of the mountains receives far less precipitation than the ocean side. Also, temperatures on the land side of the mountains are much more extreme, both for high and low temperatures, than on the ocean side (climate is further discussed in the Hydrology section).

Temperature and precipitation variations resulted in periods of glaciations, which had a major impact on the shaping of the surface topography present today. Glaciation, which started in the Pleistocene Period about 1.6 million years ago and ended about 10,000 years ago, has resulted in a wide variety of glacial carved valleys and mountains throughout the CNF. Large outwash plains and marine deltas have also formed from the deposition of sediment resulting from glaciation.

Evidence of glaciation decreases from the east to the west across the Kenai Peninsula and from south to north from the Gulf of Alaska in response to the reduction in precipitation from the Gulf to the lee side of the mountains. Storms typically approach south-central Alaska from the Gulf of Alaska and bring high amounts of precipitation, which, combined with high mountains and cold temperatures, produce heavy snow resulting in glaciers and ice fields. As the precipitation decreases westward across the peninsula and into the interior, the effects of glaciation decrease.

Ecological Hierarchy. A national hierarchal framework has been finalized for the entire Forest Service in an effort to stratify and delineate landscapes (table 1) based on biotic and environmental factors that directly or indirectly express energy, moisture, and nutrient gradients which regulate the functions of the ecosystems (USDA Forest Service 1993). The Ecological Subsection level most generally describes the overall shaping processes affecting the landscape on the Kenai Peninsula. This level attempts to place large landscapes with similar geology, lithology, geomorphic process, soil groups, sub-regional climates, and potential natural plant communities into describable units.

Western Kenai Mountains Subsection (M244Af). The Quartz Creek Landscape Assessment Area is located within the Western Kenai Mountains Subsection (M244Af). The rounded mountains are the result of frost action typical of a cold and relatively drier climate, and valleys that were initially shaped by glaciers originating in the Eastern Kenai Mountains Subsection (M244Ag). Many of the glacial landscape features of this subsection have been masked by subsequent alluvial and colluvial processes. Precipitation ranges from 20 inches in the valleys to 80 inches in the alpine; snowpack is 20 to 60 inches, respectively. The characteristic vegetation of the alpine and some of the mountain sideslopes is dominated by dwarf scrublands and herbaceous vegetation types. The remainder of the sideslopes and the valley bottoms are covered with a mixed needleleaf/broadleaf forest that is highly influenced by past fires.

Table 1. National hierarchal framework stratifying and delineating landscapes based on biotic and environmental factors regulating the function of the ecosystems

Ecological Units	Ecological Units in the Project Area	Purpose, Objectives, and General Use
Domain	Humid Temperate (200)	National planning and modeling
Division	Marine (240)	National planning and modeling
Province	Pacific Coastal Mountains Forest-Meadow (244) Pacific Gulf Coastal Forest-Meadow (245)	National planning and modeling
Section	Chugach Mountain (M244A) St. Elias Mountain (M244B) Northern Gulf Fjordlands (245A) Northern Gulf Fjordlands (M245A)	Multi-forest, statewide, & multi-agency analysis
Subsection	Tasnuna River (M244Ac) Turnigan Arm (M244Ae) Western Kenai Mountains (M244Af) Eastern Kenai Mountains (M244Ag) Chugach Icefields (M244Aa) Lowe River (M244Ab) St. Elias Icefields (M244Ad) Copper River Delta (M245Ad) Copper River (M245Ae) Kenai Fjordlands (M245Aa) Prince William Sound Mainland (M245Ab) Prince William Sounds Islands (M245Ac)	Multi- & inter-forest planning and analysis
Landtype Association	Glaciers (00) Mountain Summits (10) Mountain Sideslopes (30) Depositional Slopes (40) Moraines (60) Coastal (70) Outwash (80) Hills (90)	Forest watershed or landscape analysis planning

Landtype Association Descriptions

The Landtype Association level is the next level below the Ecological Subsection. This is the highest level in the hierarchy that describes landscape (table 1). At this level ecological units are defined by the geomorphic process and how it affects the topography, surficial geology, local climate, soils, and potential natural plant community patterns. This is the level used for forest-level planning because it is broad enough to identify and compare landscape characteristics and general limitations for management activities.

The Landtype Associations are divided into eight categories. Of these eight categories, seven are located within the project area. A brief description and management limitations are given for each Landtype Association located in the landscape assessment area below. For a more detailed explanation see the Kenai Soil Resource Inventory (Davis et al. 1980).

Mountain Summits. This association includes the ridges, peaks, cirque headwalls and basins and the associated scree slopes. Glaciation has been the most dominant historic geomorphic force which shaped the landscape. Frost fracturing has resulted in rounded mountain tops and ridges covered by a layer of loose rock. Most of the water runs off the surface where bedrock is exposed or beneath the surface where significant depths of loose rock have accumulated. The vegetation is mostly low growing forbs, grasses, and lichens where there is sufficient soil, with some willows and other woody plants in localized wet areas.

Management Limitations: The high altitude, the large amount of exposed bedrock and shallow soils, and the extremely steep slopes will all restrict management activities. Avalanches and rock fall are very common on these landscapes.

Glaciers. This association includes all active major glaciers and ice fields; they include rock peaks or nunataks. The major processes include the formation and movement of ice and all associated rock and soil.

Management Limitations: The presence of ice and perennial snow over the majority of the map unit are the major limiting factors in this unit.

Mountain Sideslopes. This category includes all sideslopes, glaciated or nonglaciated, smooth or irregular, that normally receive surface or subsurface water draining from alpine landscapes. Slope steepness normally ranges from 15 to 70 percent. The most dominant process shaping the steeper slopes in this category is erosion and transportation of sediment downslope due to gravity. Erosion from surface water usually results in a parallel drainage pattern with V-notched channels of variable depths and densities. Other soil and rock loosened by frost and water rolls down the slopes or is carried down by avalanches. This material is deposited on the lower, less steep slopes. The soils are normally medium textured, well drained, and moderately to well developed. Some of these soils on the lower slopes consist of compact glacial till which are more poorly drained and less productive for forests than other soils in the association. The upper sideslopes are commonly vegetated with low growing subalpine plants which grade into mixed communities of grasses, shrubs, and trees on the lower slopes. The location of trees is strongly dependent on disturbance by avalanches.

Management Limitations: Steep slopes, V-notches, avalanches, and the potential for erosion accelerated by management activities are the major limitations to management in this association. Wet soils will be more common at the base of longer slopes. Exposure of mineral soils must be kept to small areas on all slopes to prevent erosion and retain soil productivity. Extra care needs to be taken to retain the organic layer where soils are shallow on the hill slopes.

Depositional Slopes. This association includes the lower depositional foot slopes at the bottom of the mountain sideslopes and river terraces that have high cutbanks and are no longer affected by floods or active river cutting. These landscapes normally receive runoff water from adjacent uplands and are the depository for eroded sediment. The drainage pattern is usually dendritic. The soils are usually well drained, deep, and medium to coarse textured except immediately below long sideslopes where the drainage may be poor due to the accumulation of subsurface runoff. Some of these soils consist of compact glacial till which are more poorly drained and less productive for forests than other soils in the association. Slope gradient is usually less than 35 percent. Vegetation can range from lush grasses and herbaceous plants to old growth forests. The vegetation is strongly dependent on disturbance by avalanches.

Management Limitations: The major limitations to management in these units will be the poorly drained and wet soils normally found at the base of long sideslopes, numerous small water channels, and avalanches.

Moraines. This association includes all major glacial depositional features such as glacial moraines, esters, kettles, and kames. Occurrences are normally at the junction of two glaciers, adjacent to lower mountain side slopes, or in the bottoms of glacial valleys. Most of the relief is in mounds ranging in height from 10 to 100 feet with slope gradients of 25 to 65 percent. The soils are poorly to well drained and consist of non-sorted gravel, cobbles, and stones, in a moderate to fine textured matrix. Drainage often depends on slope rather than permeability of the soils. Trees are normally found on side slopes and tops of moraines. Wetter vegetation is commonly found in lower basins in between moraines.

Management Limitations: Large boulders in the moraines can frequently cause difficulty to numerous activities. Wet areas or wetlands in the lower areas will often require restrictions of special consideration.

Outwash. This association includes all landscapes that are a result of fluvial deposition of sediment as a result of upland erosion. Much of this association is exposed to occasional or frequent flooding depending on the proximity to rivers. Examples are alluvial plains, glacial outwash plains, braided glacial rivers and the included islands or sand bars, low relief river terraces, and narrow valley bottoms that contain a combination of the above landscapes. This association also includes large sand dunes. The soils include both poorly drained lacustrine silts and clays, and well-drained alluvial loams, sands, and gravels. The vegetation on the poorly drained, fine-textured soils will be indicative of wetlands where the surface is level, and poorly productive forests on gentle slopes. The coarse textured soils will produce highly productive forests.

Management Limitations: All the fine textured soils that occur on historic cut slopes produce landslides naturally or from incompatible management activities. The finer textured soils are commonly wet and support wetlands on level surfaces. The relatively thin organic surface layer in coarser textured soils must be retained or mixed with the mineral soils for reforestation.

Hills. This association includes hills and plateaus that do not receive surface or subsurface water flow from uplands. This excludes major rivers or creeks that may flow through the hills that originate from other areas. The surface character of these landscapes is often controlled by the stratigraphy of the bedrock. These landscapes are frequently covered by a veneer of glacial till. The soils are normally well drained, medium to coarse texture on the side slopes, and poorly drained fine to medium textured and shallow in the basins or low areas between the hills. The vegetation will usually consist of forested communities on the slopes and hilltops where the soils are well drained. The vegetation in the small basins or valleys in-between the hills will commonly be associated with wet soils or wetlands.

Management Limitations: All the sites located in the basins or low areas will likely have either wet soils or wetlands and must be managed as such. Exposure of mineral soils must be kept to small areas on all slopes to prevent erosion and retain soil productivity. Extra care needs to be taken to retain the organic layer where soils are shallow on the hill slopes.

Landtypes

Landtypes are the next level in the hierarchy and are commonly delineated at scales of 1:24,000 to 1:63,360. Geomorphic process, landform, and local relief/slope shape are usually the first criteria used to separate a landscape into landtype units. Following the convention of the classification hierarchy overlapping one level above and below the selected level (Landtype Association and Landtype Phase), landtypes are influenced by climate, lithology, and structure, soil weathering phase and vegetation, respectively. Landtypes are identifiable by visible surface features, so one can identify the kind of map unit delineation and similar delineations from either the ground or on appropriate-scale remote sensing resources once their identifying characteristics are known. Along with the differentiating classification criteria, accessory characteristics are important and useful features of landtypes. The two most common and important accessory characteristics in a landtype layer are soil and vegetation. Soil is ordinarily classified at the "family" level of soil taxonomy. Landtypes contain a predictable soil pattern, with a defined percentage of the area within a landtype. For Quartz Creek, the source for landtype soil accessory data is "Soil Resource Inventory of the Kenai Peninsula" (Davis et al. 1980), and several unpublished data sets from the CNF. Likewise, vegetation patterns must exhibit a predictable pattern and a defined percentage of an area within a landtype. Commonly, landtypes use habitat types as their vegetative characteristic. Where habitat types have not been defined, as in the Quartz Creek Watershed, either a surrogate climax plant community such as dominance type is used or a local system that relates local classifications to meet the criteria and purposes of the landtype hierarchy. For the Quartz Creek Watershed, the source for landtype vegetation accessory data is "Plant Community Types of the Chugach National Forest, South Central Alaska" (DeVelice et al. 1999).

Figure 4 shows the landtypes that occur in the Quartz Creek Watershed. Soil data are relatively limited in the assessment area, but there is coverage of the major valley bottoms and adjacent lower slopes (figure 5). (The map unit legend for the soils coverage includes the map number; the map unit identification is presented in table 2.)

The soil data and mapping available for the Quartz Creek Watershed covers only the major valley bottoms/adjacent slopes and road corridor in the Quartz Creek Watershed. This survey does not meet "Terrestrial Ecological Unit Inventory" (TEUI) standards for soils (2005), or National Cooperative Soil Survey (NCSS) standards for inventory. The rest of the area has no soil data at either the plot or polygon level.

Composition of each unit (subsection, landtype association, landtype, and soil management unit) in acres is presented in tables 2–5.

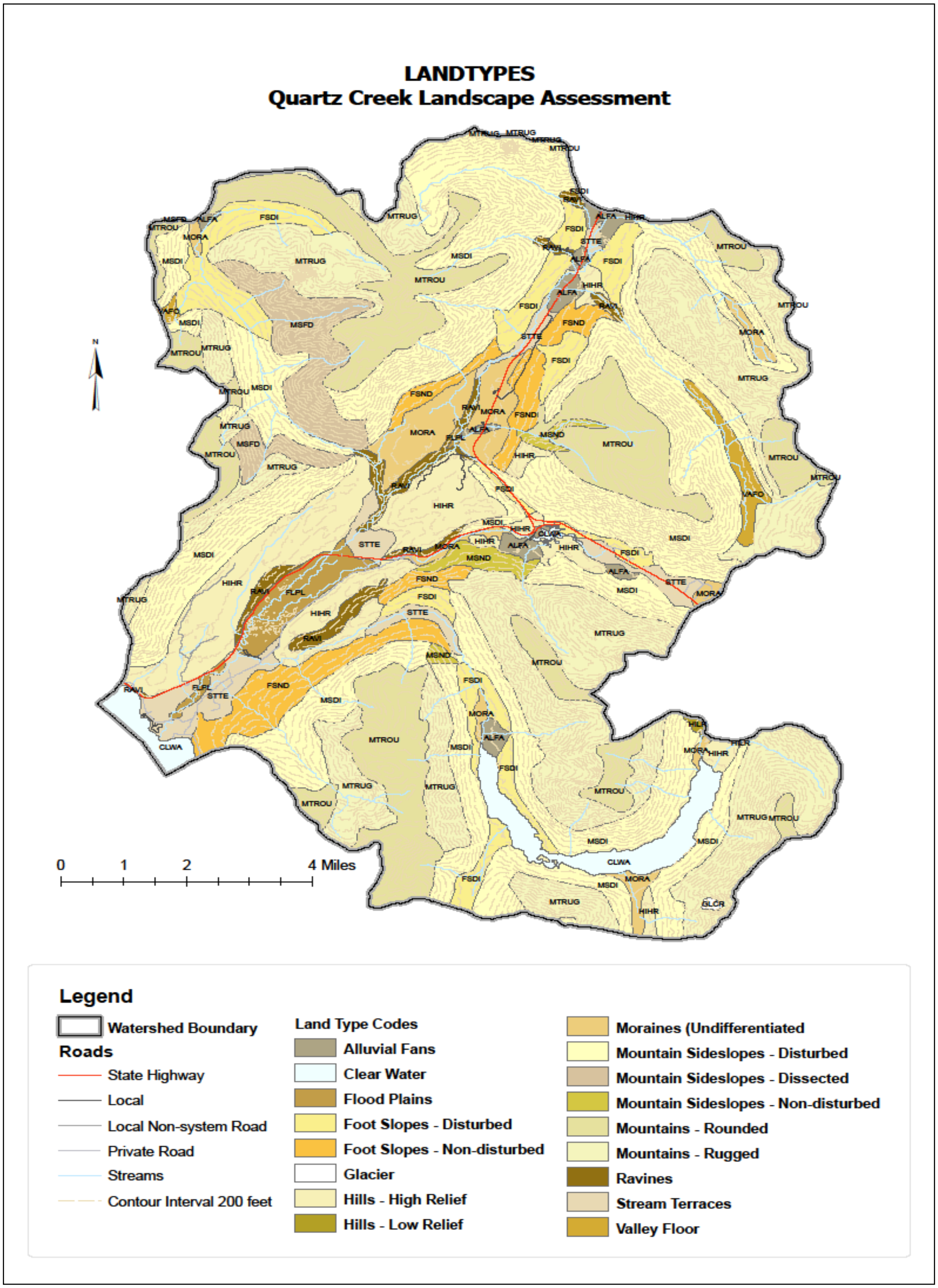

Figure 4. Landtypes in the Quartz Creek Watershed

Table 2. Dominant soils at the landtype level in the Quartz Creek Watershed

Map Unit Symbol	Acres	Dominant Soil Subgroup(s), Family, Mineralology Class, and Slope Class (%)
101A	16	Typic Cryorthods, medial-skeletal, mixed; 0-8% slope
101B	444	Typic Cryorthods, medial-skeletal, mixed; 9-12% slope
101C	2,508	Typic Cryorthods, medial-skeletal, mixed; 16-25% slope
101D	3,655	Typic Cryorthods, medial-skeletal, mixed; 26-45% slope
101E	1,620	Typic Cryorthods, medial-skeletal, mixed; 46-65% slope
101F	141	Typic Cryorthods, medial-skeletal, mixed; 66-100% slope
102C	43	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 16-25% slope
102D	170	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 26-45% slope
102E	314	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 46-65% slope
102F	84	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 66-100% slope
103A	66	Typic Cryorthods, coarse-loamy, mixed; 0-8% slope
103B	191	Typic Cryorthods, coarse-loamy, mixed; 9-15% slope
103C	142	Typic Cryorthods, coarse-loamy, mixed; 16-25% slope
103D	29	Typic Cryorthods, coarse-loamy, mixed; 26-45% slope
105A	73	Typic Cryorthods, sandy-skeletal, mixed; Trypic Cryorthods, loamy-skeletal, mixed; 0-8% slope
202A	106	Dystric Cryochrepts, loamy-skeletal, mixed; 0-8% slope
202B	340	Dystric Cryochrepts, loamy-skeletal, mixed; 9-15% slope
202E	65	Dystric Cryochrepts, loamy-skeletal, mixed; 46-65% slope
204A	148	Histic Cryaquepts, loamy-skeletal, mixed; Histic Cryaquepts, coarse-silty, mixed; 0-8% slope
204B	202	Histic Cryaquepts, loamy-skeletal, mixed; Histic Cryaquepts, coarse-silty, mixed; 9-15% slope
205B	16	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryorthods, loamy-skeletal, mixed; 9-15% slope
205C	54	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryorthods, loamy-skeletal, mixed; 16-25% slope
205D	771	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryorthods, loamy-skeletal, mixed; 26-45% slope
205E	145	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryorthods, loamy-skeletal, mixed; 46-65% slope
206B	122	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryaquents, loamy-skeletal, mixed; 9-15% slope
207A	163	Typic Cryumbrepts, loamy-skeletal, mixed; 0-8% slope
207C	15	
208B	42	Dystric Cryochrepts, loamy-skeletal, mixed; 9-15% slope
208C	126	Dystric Cryochrepts, loamy-skeletal, mixed; 16-25% slope
208D	534	Dystric Cryochrepts, loamy-skeletal, mixed; 26-45% slope
208E	252	Dystric Cryochrepts, loamy-skeletal, mixed; 46-65% slope
208F	16	Dystric Cryochrepts, loamy-skeletal, mixed; 66-100% slope
301B	6	Typic Cryaquents, sandy-skeletal, mixed; 9-15% slope
302A	407	Typic Cryorthents, sandy-skeletal, mixed; 0-8% slope
303A	616	Typic Cryaquens, coarse-loamy over sandy-skeletal, mixed; 0-8% slope
303B	13	Typic Cryaquens, coarse-loamy over sandy-skeletal, mixed; 9-15% slope
304A	25	Typic Cryofluvents, coarse-loamy, loamy-skeletal, mixed; 0-8% slope

Map Unit Symbol	Acres	Dominant Soil Subgroup(s), Family, Mineralology Class, and Slope Class (%)
306B	30	Typic Cryaquents, loamy-skeletal, mixed, non-acid; 9-15%
306C	55	Typic Cryaquents, loamy-skeletal, mixed, non-acid; 16-25%
401A	382	Terric[1] Borosaprists (Terric Cryosaprists), loamy-skeletal, euic
GP	14	
RW	31	
W	124	
Total	**14,316**	

[1] The particle-size classes that are to be recognized at the family level for mineral material in Terric (an unconsolidated mineral layer at least 30 centimeters thick beneath the surface tier) subgroups of organic soils are fragmental, sandy, sandy-skeletal, loamy, loamy-skeletal, clayey, and clayey-skeletal.

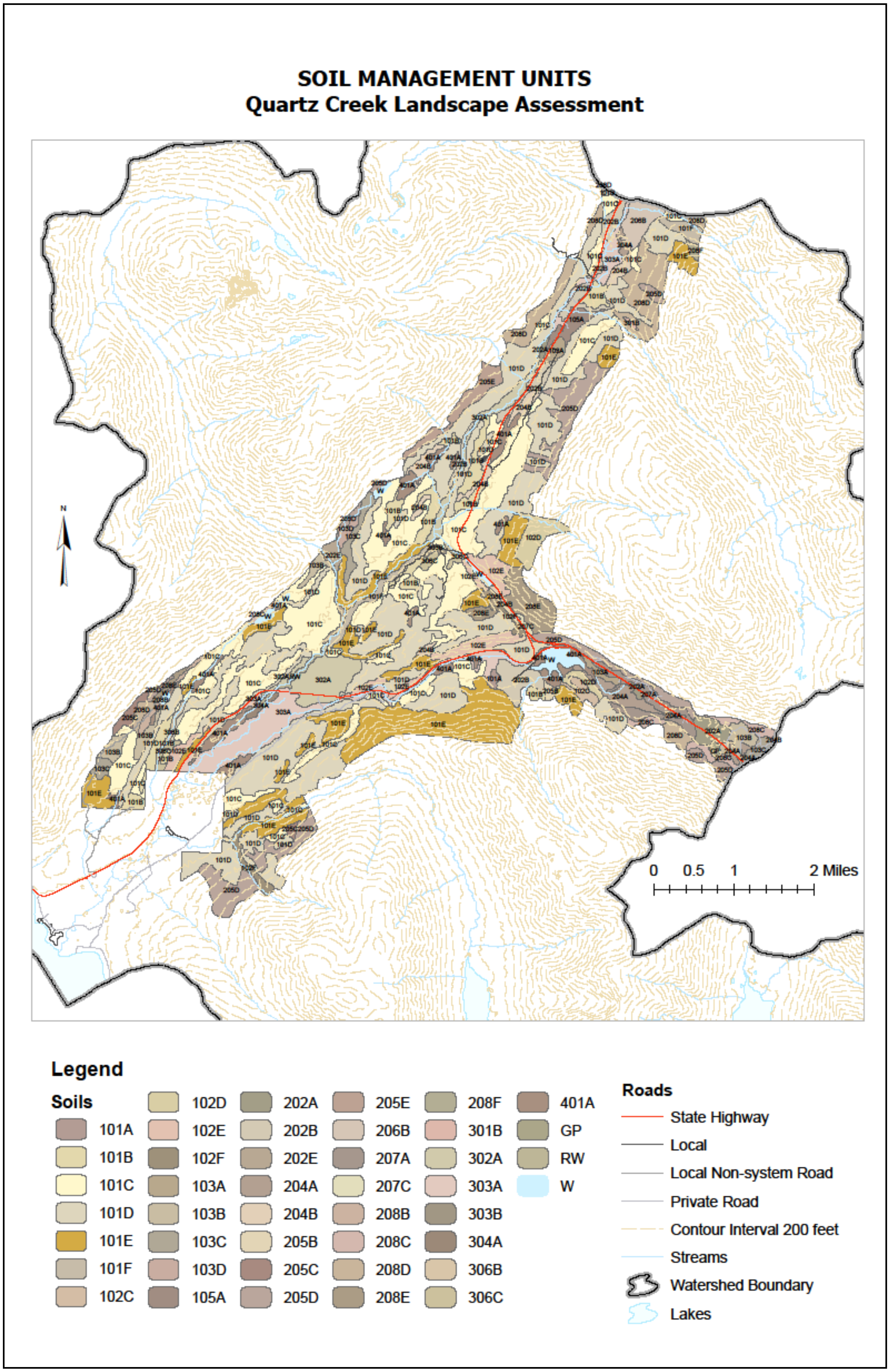

Figure 5. Quartz Creek soil management units

Table 3. Subsection composition in Quartz Creek Watershed

Eco Unit Code	Acres
Western Kenai Mountains (M24Af)	73,826
Eastern Kenai Mountains (M244Ag)	1,261
Total	**75,086**

Table 4. Landtype association and landtype inventory composition in Quartz Creek Watershed

Landtype Association	Acres
Mountain Summits (10)	27,128
Mountain Sideslopes (30)	26,188
Depositional Slopes (40)	10,455
Outwash (80)	980
Hills (90)	8,442
Clear Water	1,893
Total	**75,086**
Landtype Codes	**Acres**
ALFA-alluvial fans	865
CLWA-clear water	1,935
FLPL-flood plains	1,119
FSDI-foot slopes (disturbed)	4,145
FSND- foot slopes (non-disturbed)	2,835
GLCR-glacier	35
HIHR-hills (high relief)	5,622
HILR-hills (low relief)	52
MORA-moraines (undifferentiated)	2,274
MSDI-mountain sideslopes (disturbed)	22,253
MSFD- mountain sideslopes (dissected)	2,415
MSND- mountain sideslopes (non-disturbed)	634
MTROU-mountains (rounded)	10,556
MTRUG-mountains (rugged)	16,550
RAVI-ravines	1,156
STTE-stream terraces	2,101
VAFO-valley floor	539
Total	**75,086**

Hydrology

Climate

The Quartz Creek Watershed is influenced by the maritime climate of Prince William Sound to the east, as well as the mountainous climate of the interior Kenai Peninsula. Temperatures within the watershed average about 36 degrees F in the lower elevations of the watershed, decreasing with increasing elevation. In the lower elevation areas, average maximum July temperatures reach 68 degrees F and average minimum January temperatures drop to 6 degrees F (table 5) (Western Regional Climate Center 2009).

The watershed lies in a rain shadow created by the Kenai Mountains to the east, which captures much of the moisture in the storms that circulate over Prince William Sound. Average annual precipitation ranges from about 20 to 30 inches in the lower elevations of the watershed and 40 to over 60 inches in the higher elevations (table 5) (Western Regional Climate Center 2009; USDA Natural Resources Conservation Service 2009). Precipitation is the heaviest in September and October, and winter months receive more precipitation than summer months. April, May, and June are generally the driest months of the year.

Table 5. Weather station and snow site data for the Quartz Creek Watershed

Station	Location				Temperature		
	Elevation (ft)	Latitude (ddmm)	Longitude (ddmm)	# of years of data	Average Daily Temp (F)	Average Max July Temp (F)	Average Min Jan Temp (F)
Cooper Landing 6W [1]	380	6029	14958	31	36.1	68.4	10.1
Moose Pass 3NW [1]	480	6030	14926	35	35.6	66.6	6.2
Summit Creek [3]	1400	6037	14932	18	-	-	-
Snug Harbor Road [2]	500	6024	14921	27	-	-	-
Moose Pass [2]	700	6031	14930	39	-	-	-

Station	Precipitation						
	Annual Precip (inches)	Average March 1 Snowpack Depth		Average May 1 Snowpack Depth		Peak snowpack of record (by SWE)	
		inches	SWE*	inches	SWE	inches	SWE
Cooper Landing 6W [1]	21.6	-	-	-	-	-	-
Moose Pass 3NW [1]	28.2	-	-	-	-	-	-
Summit Creek [3]	30.2	38	10.4	14	6.7	48	16
Snug Harbor Road [2]	-	20	5.1	12	2.5	40	13.6
Moose Pass [2]	-	22	6.3	7	2.5	45	16.8

[1] Weather station data (WRCC, 2009); [2] Snow course data (USDA NRCS, 2009)
[3] SNOTEL Site (USDA NRCS, 2009); * SWE=Snow water equivalent

Snow generally falls at all elevations of the watershed from October to April, although winter warm spells can bring rain to the lower elevations. Snowfall and snowpack in the watershed increase dramatically with elevation. The lower elevations of the watershed receive about 50 to 100 inches of snow annually, with an average maximum annual snowpack of about 10 to 20 inches. Higher elevations in the watershed receive considerably more snow, with average maximum annual snowpacks over 40 inches (USDA Natural Resources Conservation Service

2009; Western Regional Climate Center 2009) (table 5). In the low elevations, snowfall accounts for less than 25 percent of the total annual precipitation. In the higher elevations, snowfall accounts for over 50 percent of the total annual precipitation.

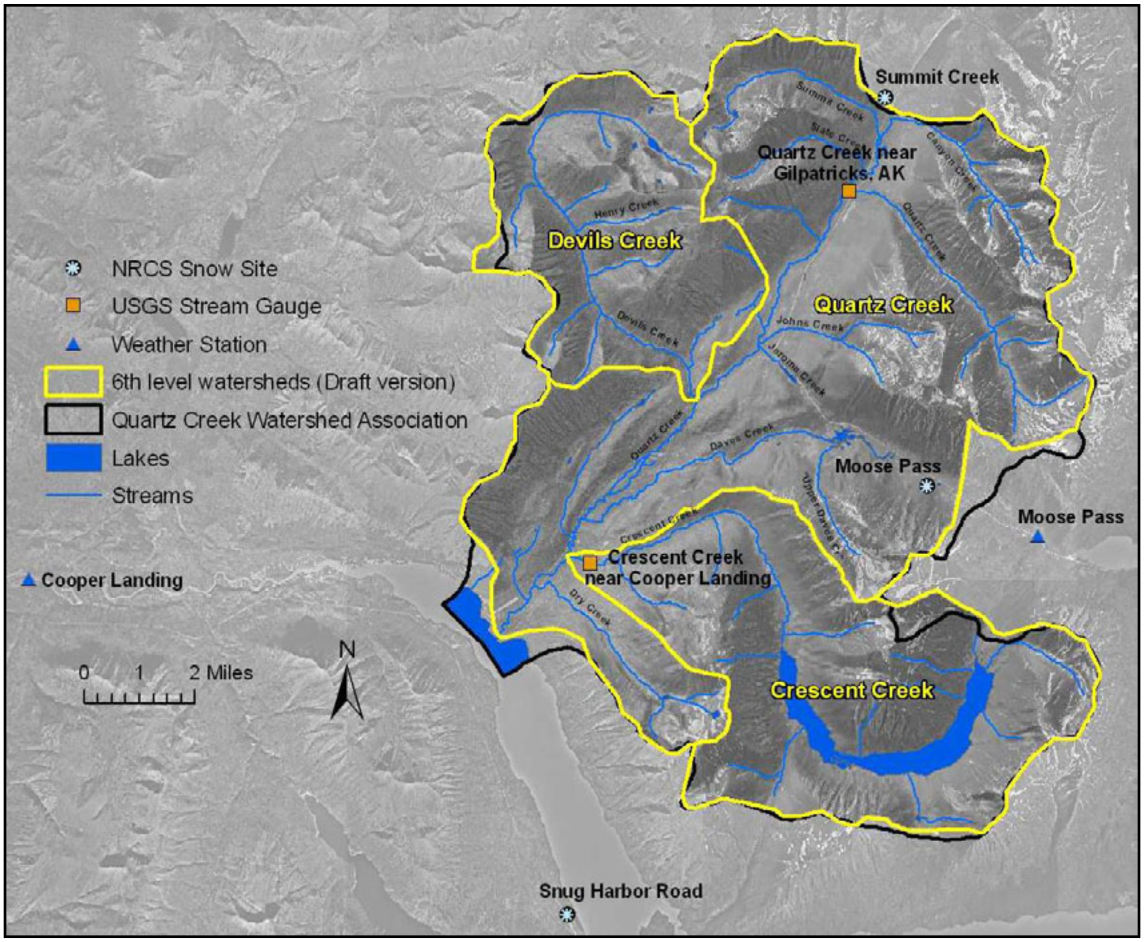

Figure 6. Subwatersheds and data collection sites in the Quartz Creek Watershed

Watershed Morphology

The Quartz Creek Watershed covers 75,086 acres (117 square miles), with a length of about 12 miles. The watershed is defined by the Quartz Creek Watershed Association, as delineated by the CNF. The watershed is also defined by the Devils Creek-Quartz Creek 5th-level watershed, which includes the Quartz Creek, Devils Creek, and Crescent Creek 6th-level subwatersheds defining each of the three main drainages (figure 6). These watershed delineations are in draft form because the statewide Watershed Boundary Dataset is currently in development (using national standards). The Quartz Creek Watershed drains to the southwest into Kenai Lake and the Lower Kenai River Watershed. Elevations within the watershed range from 426 feet at the mouth of Quartz Creek at Kenai Lake to 5,320 feet on a peak just north of Crescent Lake. Currently, glaciers are mostly absent from the watershed, covering only about 360 acres, or 0.5 percent of the watershed. These remnant glaciers are shrinking.

The main streamcourses, Quartz Creek and Daves Creek, lie within wide, U-shaped valleys that were glacially carved. Smaller tributaries, including Devils Creek and the upper portion of Quartz Creek, lie within steep, V-shaped valleys carved by fluvial erosion. Hanging valleys exist where glacially carved valleys are perched higher than the main valley of Quartz Creek. The most prominent hanging valley is that occupied by Crescent Lake.

Including the 506-acre portion of Kenai Lake at the mouth of the watershed, lakes cover 2,104 acres, or 2.8 percent of the watershed. The largest lakes in the watershed include the 1,374-acre Crescent Lake, the 55-acre Tern Lake, and the 14-acre Jerome Lake. There are no man-made lakes or reservoirs in the watershed. Crescent Lake occupies a glacially sculpted hanging valley at 1,450 feet elevation. Tern Lake is a shallow lake formed by the damming effect of an alluvial fan in a flat valley floor surrounded by steep mountains.

Numerous large avalanche paths exist within the Quartz Creek Watershed. A large number of these are located in the backcountry where they may have a limited effect on human uses. However, some avalanche paths can influence the Seward and Sterling Highways, backcountry trails such as the Devils Pass and Summit Creek Trails, and developed land, including the Tern Lake area and the Avalanche Acres Subdivision. March and Robertson (1982) describe several large avalanche paths on the south-facing slopes northwest of Tern Lake. These avalanche paths have 3,000 to 4,000 feet of relief, and the runout zones regularly impact the Seward Highway (figure 7). An avalanche path has also impacted the Sterling Highway one-half mile west of Tern Lake on the north side of the highway, and a large avalanche path exists on the south side of Tern Lake, with a runout zone extending onto the lake.

Figure 7. Avalanche runout zones near Tern Lake (from Blanchet [2003])

Streams

A total of 132 miles of mapped streams lie in the watershed, based on stream mapping by the Forest Service. This represents a drainage density of approximately 1.1 stream miles per square mile. A total of 12.8 miles, or 10 percent of these streams, are artificial paths through lakes. Quartz Creek is the largest stream in the watershed, and the major tributaries are Devils Creek, Crescent Creek, and Daves Creek. Channel types were assigned to mapped streams based on the "Tongass National Forest Channel Type User Guide" (USDA Forest Service 1992) (figure 8). About 14 percent of the mapped streams in the watershed are floodplain (FP) channels. Lower Quartz Creek is a low gradient floodplain channel (FP4) and a wide low gradient floodplain channel (FP5). Daves Creek downstream of Tern Lake is a narrow floodplain channel (FP3) and a low gradient floodplain channel (FP4). Moderate gradient contained (MC) channels comprise 11 percent of the mapped streams. The larger, confined tributary channels, including Crescent Creek and Devils Creek, are largely moderate width and incision contained channels (MC2). High gradient contained (HC) channels comprise 47 percent of the mapped streams, including most of the smaller tributaries. Alluvial fan (AF) channels, comprising 6 percent of the streams, exist where high gradient streams encounter lower gradient valleys.

Quartz Creek is the longest and largest stream in the Quartz Creek Watershed, originating at a high pass near the south end of the Mills Creek Watershed and flowing into Kenai Lake 19 miles downstream (figure 8). It flows through a small hanging valley before dropping down to the larger glacially carved valley and the Seward Highway. The lower 11 miles of Quartz Creek is a floodplain channel, decreasing in gradient and increasing in sinuosity before flowing into the north end of Kenai Lake.

Wetlands

Wetlands cover 3,212 acres, or 4.3 percent of the Quartz Creek Watershed (figure 10). About 2.3 percent of the watershed is covered by palustrine wetlands, or areas associated with swamps, bogs, ponds, beaver ponds, and floodplains. Palustrine wetlands are particularly prominent in the valley floor along the lower 4 miles of Quartz Creek. Lacustrine wetlands, or wetlands associated with lakes, cover 1.9 percent of the watershed and include Crescent and Tern Lakes. Wetlands are mostly absent in the uplands of the watershed, although there are some scattered palustrine wetlands in the upper valleys of some of the larger tributaries.

Streamflows

Historical streamflow data for the Quartz Creek Watershed include 10 years of peak flow data from the upper portion of Quartz Creek, and 35 years of peak and daily flow data from the mouth of Crescent Creek, the largest tributary to Quartz Creek (U.S. Geological Survey 2009) (figure 11). No gauging stations are currently in operation in the watershed. The flow regimes in Quartz Creek and its tributaries are unaffected by glaciers. Streamflows are controlled primarily by snowmelt in the early summer and rainfall runoff in the spring, summer, and fall. Spring runoff generally begins in mid- to late-April, with flows rising rapidly to summer snowmelt peaks in mid- to late-June. Flows gradually decrease throughout the remainder of the summer as the snowpack is depleted. Late summer and fall rainstorms are capable of producing large peak flows that can exceed the summer snowmelt peak flows. These high magnitude events are generally short in duration, although continuous rainstorms can elevate flows for longer periods of time. Winter flows generally remain low from January to mid-April as a result of cold temperatures and ice.

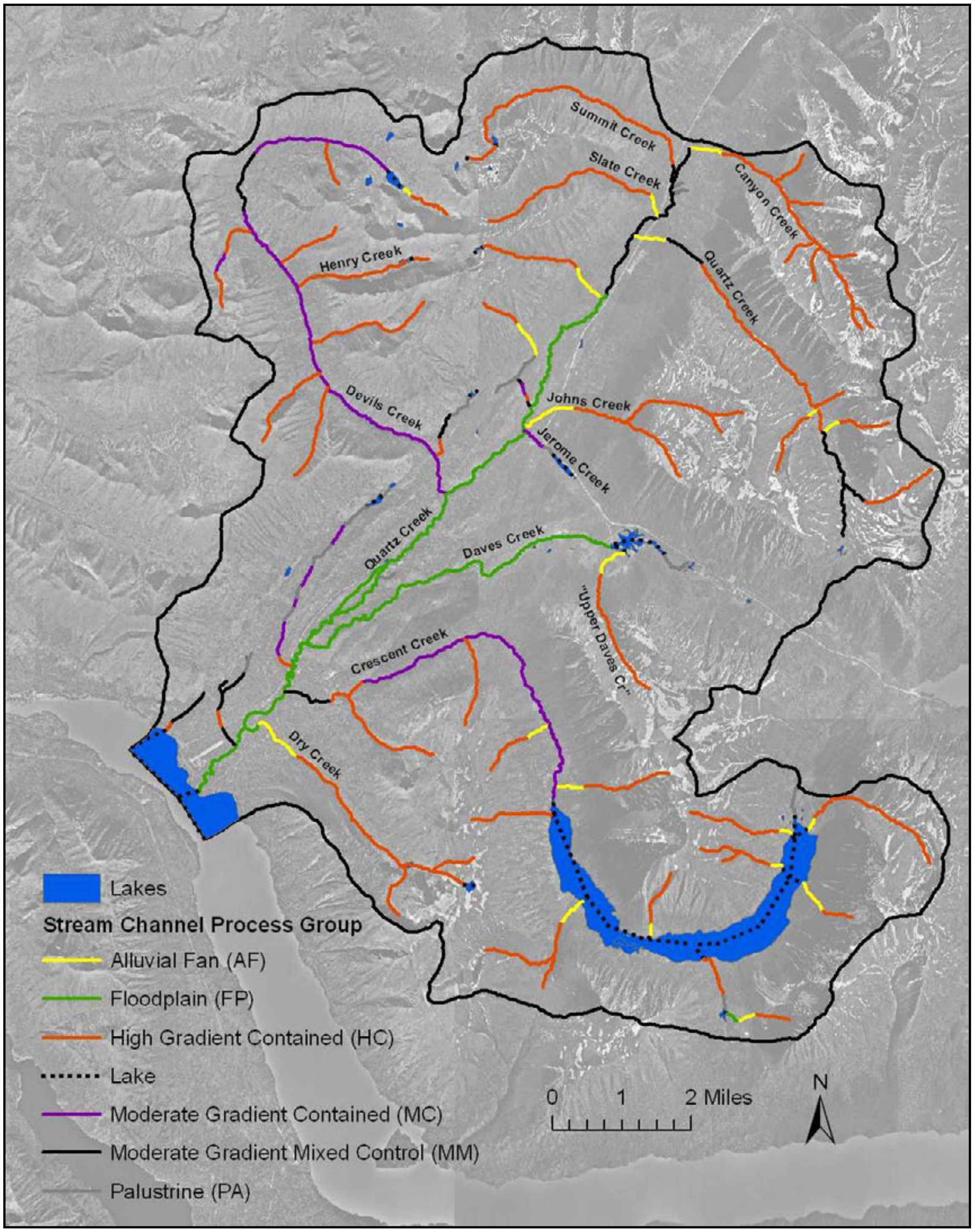

Figure 8. Stream channel type process groups in the Quartz Creek Watershed (data from Forest Service)

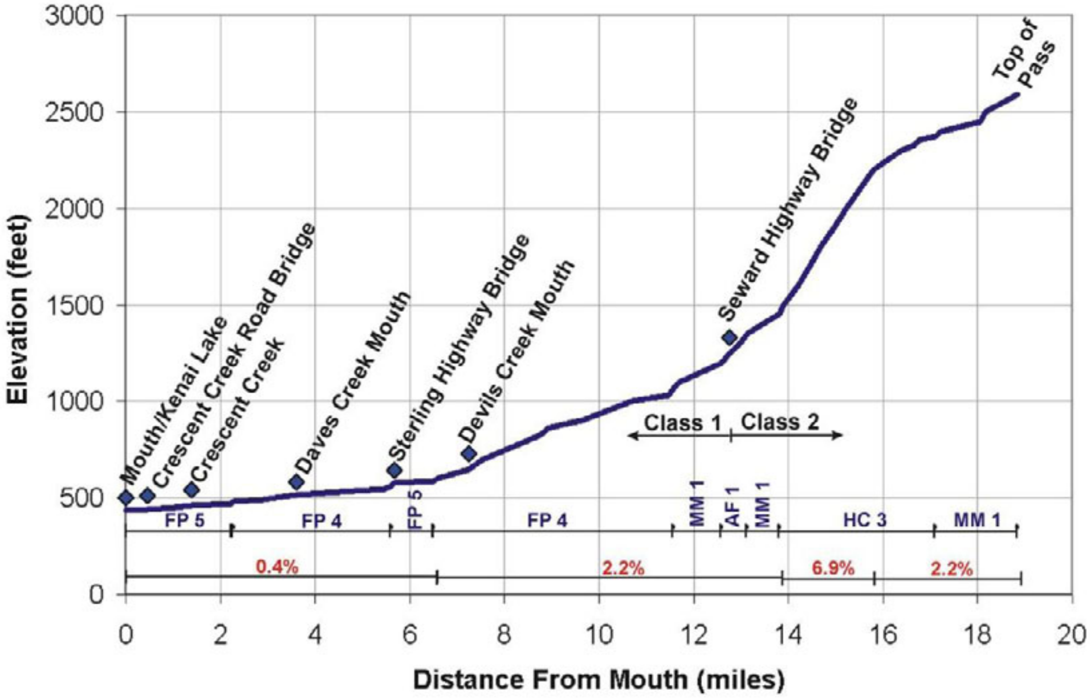

Figure 9. Generalized longitudinal profile of Quartz Creek showing locations of prominent features, average slopes, and channel types (vertical exaggeration 20x).

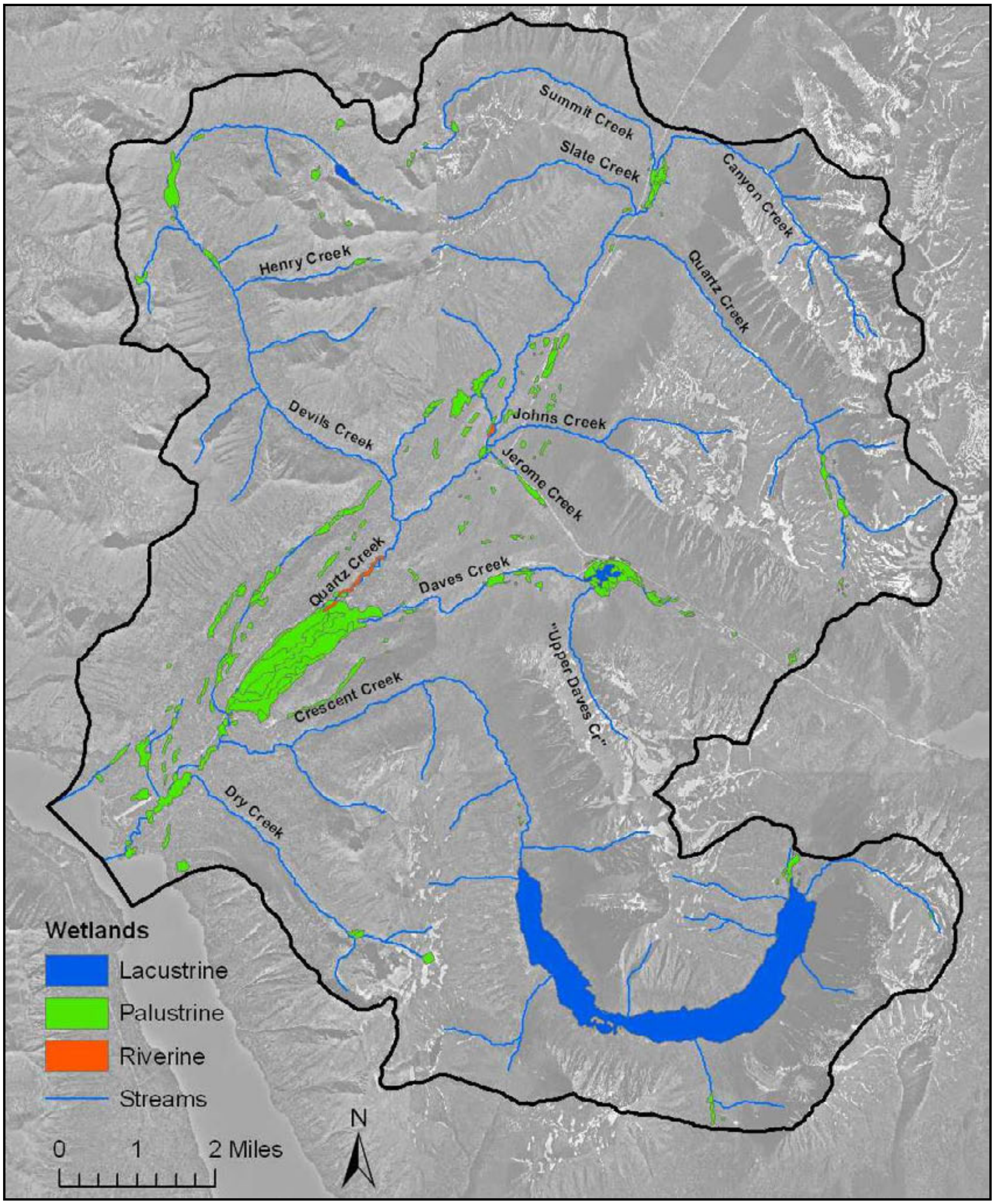

Figure 10. Wetland classification for the Quartz Creek Watershed (data from U.S. Fish and Wildlife Service wetland mapping [1997])

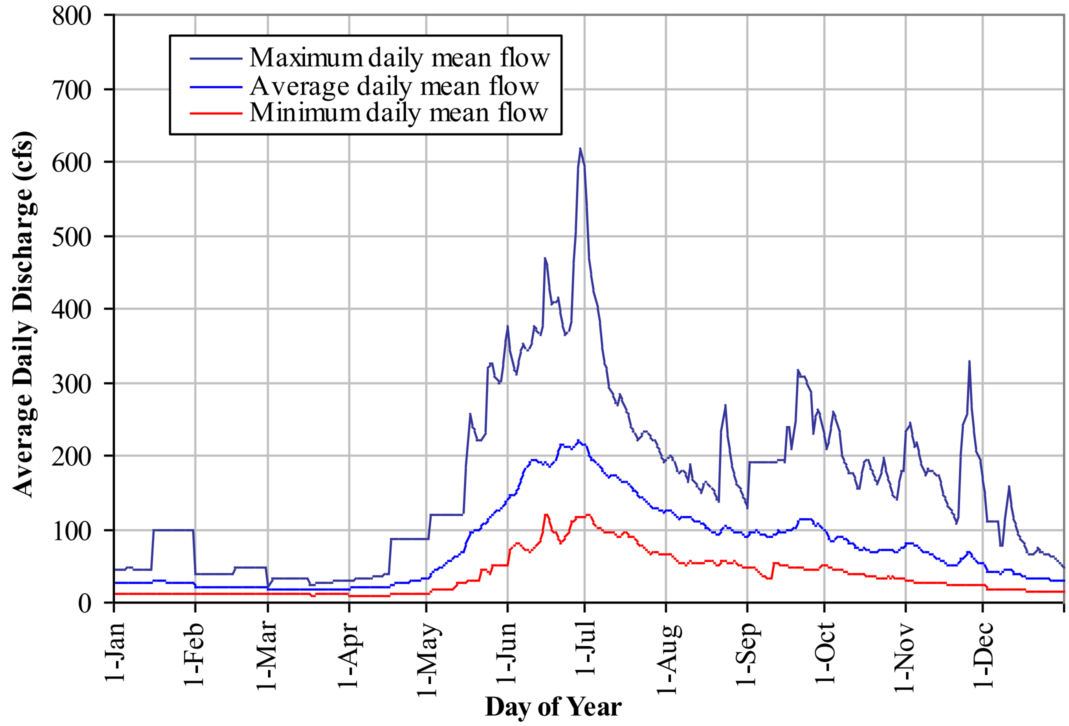

Figure 11. Average daily streamflows for Crescent Creek at its mouth (period of record 1949 to 1966 (U.S. Geological Survey [2009])

Peak flows on Crescent Creek at its mouth average about 200 cfs (cubic feet per second), with winter low flows averaging 10 to 30 cfs (U.S. Geological Survey 2009). The magnitude of the 50-year flood is approximately 1,170 cfs, or 37 cfs per square mile (Curran et al. 2003). Crescent Creek experiences smaller flood peaks than other streams in the watershed as a result of the attenuation of flows in Crescent Lake. Throughout the watershed, unit discharges (per square mile of drainage area) for the 50-year flood range from less than 40 cfs per square mile in Crescent Creek to over 100 cfs per square mile in upper Quartz Creek, where no flow attenuation occurs. Unit discharges increase with elevation in the watershed as well as to the east, where precipitation is slightly higher.

Water Quality

Water quality data are limited for the Quartz Creek watershed. Data from two U.S. Geological Survey gauging stations in the watershed are available from 1950 to 1978 (U.S. Geological Survey 2009). These two sites show fairly similar chemical water quality characteristics, and data are within the Alaska State standards (Alaska Department of Environmental Conservation 2006), with the exception of two pH readings slightly below the State standard. Because of the limited development in the analysis area, water quality is generally pristine. Because of the limited influence of glaciers in the watershed, the water in Quartz Creek is generally clear, except during early summer runoff and other high water events. Daves Creek carries visible glacial silt during periods of glacial melt in the summer.

No streams in the watershed are listed on the 303(d) list of impaired water bodies, and sources of water pollutants are limited. Potential sources of water quality impairment include hydrocarbons entering Quartz Creek and its main tributaries from roads along the highway corridors, residential pollutants upstream of Tern Lake, and sediment entering these streams from natural and artificially eroding hillslopes and banks. Sources of sediment related to human uses include the cut and fill slopes of roads and highways. Also, bank erosion from angler trampling has the potential to increase sediment loads and turbidity in streams such as Quartz Creek, when high flows encounter raw, eroding banks.

Vegetation and Ecology

A wide variety of plant communities occur in the Quartz Creek Landscape Assessment Area. These plant communities are shaped by an equally diverse array of processes including anthropogenic disturbance, natural disturbance, and forest succession.

The plant communities in the assessment area include hardwood forest, softwood forest, mixed hardwood/softwood forest, riparian areas, tall shrub-lands, low shrub-lands, muskeg, alpine areas, and grasslands. Softwood forests are generally Lutz spruce (*Picea* x *lutzii*, a hybrid between white spruce [*Picea glauca*] and Sitka spruce [*Picea sitchensis*]), black spruce (*Picea mariana*), mountain hemlock (*Tsuga mertensiana*), or mixed spruce/hemlock stands. Hardwood forests include pure and mixed stands of cottonwood (*Populus balsamifera*), birch (*Betula papyrifera*), and aspen (*Populus tremuloides*). Mixed hardwood/softwood stands include birch, willow, spruce, and hemlock. Non-forested plant communities in the landscape assessment area include grass- and forb-dominated alpine areas, tall shrublands, and low shrublands. Non-plant communities comprised of rock, snow, and ice are present at higher elevations.

Avalanches, seasonal flooding, wind events, insect and disease outbreaks, and occasional fires are the principal natural disturbances that shape the plant communities within the assessment area. Major disturbances cause the forested plant communities in this area to return to an early-seral forest type, which would include any of the hardwoods listed above. When these events occur as minor disturbances, they generally create early-seral patches within a stand that is in late-seral or climactic condition. Alternatively, minor disturbances may create small gaps that release late-seral species already present in the understory, permitting them to reach the canopy.

Anthropogenic disturbance includes use and maintenance of recreation facilities, human-caused wildfire, and fire suppression. Use and maintenance of recreation facilities should be considered a minor disturbance, because the use does not replace the stand. Human-caused wildfire can be either a minor or major disturbance. As a minor disturbance, it could create early-seral patches within late-seral stands, or possibly promote individual late-seral species trees into the canopy. As a major disturbance, it would create entirely new stands of early-seral species. Fire suppression should be considered as a process that shapes the landscape. As fires are suppressed, the landscape trends toward having fewer large patches of early-seral forest.

Botany and Weeds

Sensitive Plants. There are no federally listed threatened, endangered, or proposed plant species on the CNF. A total of 18 Region 10 sensitive plant species are known or suspected to occur on the CNF: Of these, 11 have potential habitat in the landscape assessment area, 5 probably do not have adequate habitat, and 2 do not occur in the assessment area (appendix A). The one known sensitive species that occurs within the assessment area is Pale poppy (*Papaver alboroseum* Hult.).

Invasive Plants. Invasive species, a subset of nonnative species that are characterized by rapid spread and takeover of native habitats, are limited in this landscape due largely to Alaska’s relatively severe climate and low levels of anthropogenic disturbance (Carlson and Shephard 2007). Invasive species are found mostly along railroads, highways, trails, and in other developed areas.

In general the CNF is not currently experiencing major problems of nonnative invasive plants. However, surveys along major travel corridors, trails, and streams in the landscape area have found nonnative plants in almost all areas surveyed (Duffy 2003; DeVelice 2003; Chumley and Klauser 2006; and Mohatt 2009). All types of human use including recreation, infrastructure, road construction, and revegetation may contribute to the introduction and spread of nonnative species.

Fire and Fuels

Past and present wildfire (Potkin 1997) has a predominant influence on the composition and structure of the forested landscape of the Kenai Peninsula. Fire is a natural disturbance process in the Quartz Creek Watershed, but wildfire frequency and existing vegetation structure have clearly been altered since European settlement. In addition, prescribed burns have been used to manage health and safety risks and promote higher quality wildlife habitat, particularly for moose.

There are three distinct areas of fire frequency that will be discussed in this document: prehistoric (pre-1740), settlement (1741–1913) and post-settlement (1914 to present). Forests on the peninsula had not sustained timber harvest prior to 1740. Uncut forests on the Peninsula provide a rare opportunity to discern the natural dynamics of vegetation as the landscape becomes increasingly subjected to human and insect disturbances.

Aquatic Species and Habitats

The Quartz Creek Watershed contains 132 miles of stream; 31 miles of class 1 streams producing anadromous fish and or containing adfluvial lake and stream habitat, 58 miles of class 2 streams which contain resident fish species, and 43 miles of class 3 headwater non-fish bearing streams (figure 12). In addition, the Quartz Creek Watershed has over 3 square miles of lakes: Crescent Lake 1,374 acres (2.1 square miles), Tern Lake 55 acres (0.1 square miles), Jerome Lake 14 acres (< 0.1 square miles) and a series of small alpine lakes in the Gilpatrick Mountains. All five species of Pacific salmon; Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha),* and chum (*Oncorhynchus keta)* are indigenous to the Quartz Creek Watershed and contribute to the Kenai River and Cook Inlet sport and commercial fisheries. In addition, Quartz Creek and tributaries also support indigenous populations of rainbow trout (*Oncorhynchus mykiss*), Dolly Varden char (*Salvelinus malma),* dwarf Arctic char (*Salvelinus alpinus taranetzi*), slimy sculpin (*Cottus cognatus*), round whitefish (*Prosopium cylindraceum*), and threespine stickleback (*Gasterosteus aculeatus aculeatus*).

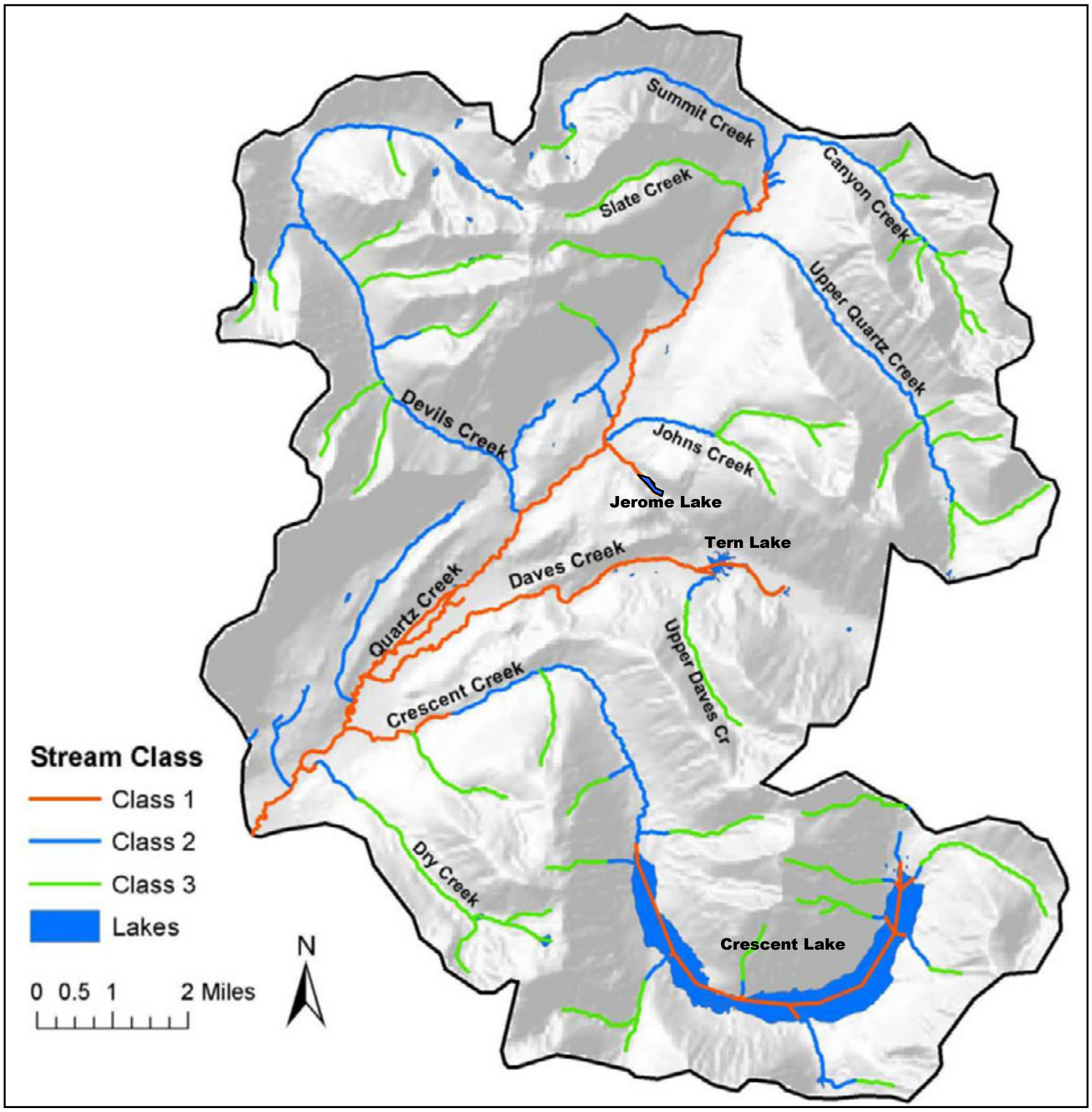

Figure 12. Fish habitat stream classification in the Quartz Creek Watershed (data from Forest Service; classification system from USDA Forest Service [2001])

Table 6. Fish habitat stream classification (USDA Forest Service 2001) in the Quartz Creek Watershed

Stream Class	Description	Miles of stream	Percent of total
Class 1	Streams with anadromous or adfluvial lake and stream habitat	31	24
Class 2	Streams with resident fish populations; generally steep (6–15% gradient); can include streams from 0–5% gradient without anadromous fish	58	44
Class 3	Streams with no fish populations that have potential water quality influence on downstream aquatic habitats	43	32

Source: U.S. Forest Service

Terrestrial Species and Habitats

Terrestrial habitats include a mosaic of wetland and upland habitats. Diverse vegetation types and structures provide diverse habitats for nearly 200 species commonly found on the Kenai Peninsula. The most current data on existing vegetation structure is available from recent mapping work by the Kenai Peninsula Borough (KPB) from 2007, using Ikonus imagery (see appendix B). The KPB cover classes describing small, medium, and large trees are described in appendix B.

The majority (74 percent) of the watershed is non-forested. Approximately 30 percent is either barren/snow/ice and another 44 percent is alpine and subalpine zones. Alpine tundra (17,027 acres) and grassy meadows (154 acres) provide summer range and some winter range for mountain goat, Dall sheep (*Ovis dalli*), caribou, and other species. Subalpine alders (15,658 acres), willow and other shrubs (268 acres), and wetlands (134 acres) occur on the sideslopes and alluvial valley bottoms. These areas provide food and cover for a diverse array of large and small mammals such as moose and bear, and migratory and resident birds.

Forested areas are generally below 1,500 feet, and are primarily pole-size mountain hemlock, large Lutz spruce, and large aspen/birch communities (table 7). Old growth or mature forests provide potential nesting habitat for goshawks, neotropical migrants, and raptors. These areas provide thermal cover, hiding cover, and denning areas for large mammals; travel corridors for moose, bear, wolverine, and wolves; and winter foraging areas for mountain goats. Some larger diameter and/or old growth mountain hemlock and Lutz spruce trees may occur on bench areas, lower slopes, and just below low ridges. Mountain hemlock dominates stands that occur on ridges and convex slopes, providing potential nesting habitat for goshawks, winter foraging habitat for mountain goats, and bedding areas for bear and moose. Canopy gaps with devil’s club and steep slope areas with mountain hemlock/blueberry provide good berry foraging areas for bears. Broadleaf forest types, such as mature birch in the stem exclusion phase, support populations of other species of migratory songbirds, which include several species of thrushes and warblers. Succession leaves paper birch snags present, providing good habitat for cavity nesting birds.

Early-seral or stand-initiation habitats (Oliver 1996) are limited (420 acres) and provide feeding habitat for moose, wolves, snowshoe hare, and lynx, and nesting habitat for neotropical migrants such as sparrows and warblers. Some early-seral habitat may be available as well in harvest areas (468 acres).

Pure stands of large aspen or birch, and areas of black spruce are rare. These areas provide habitat for migratory birds and other species.

Salmon runs in the Quartz Creek, Daves Creek, lower Crescent Creek, and Kenai Lake associated tributaries are an important seasonal source of food and support populations of many terrestrial species of wildlife, including brown and black bear, bald eagles, and wolves. Wetlands provide important nesting and foraging habitat for sensitive species such as trumpeter swans, and other waterfowl.

Table 7. Existing vegetation and percent of the watershed

Quartz Creek Landscape	Acres	Percent of Total
Black Spruce, Seed/Sap	146	0
Aspen/Birch, Seed/Sap	169	0
Birch, Seed/Sap	251	0
Aspen, Large	361	0
Black Spruce, Pole	409	1
Harvest Area	468	1
Aspen/Birch, Pole	622	1
Birch, Large	752	1
Cottonwood, Large	861	1
Birch, Pole	1,510	2
Water	2,165	3
Mountain Hemlock, Large	2,585	3
White Spruce, Large	3,016	4
Aspen/Birch, Large	3,089	4
Mountain Hemlock, Pole	3,208	4
Barren/Snow Ice	22,241	30
No Structure	33,235	44
Total	**75,086**	**100**

Wildfire, spruce bark beetle (*Dendroctonus rufipennis* Kby) infestations, and other natural processes such as avalanches, flooding, and human activities affect wildlife habitat and continue to be the factors that influence the structure, distribution, and functions of habitat throughout the watershed.

The human activities and development that affect wildlife habitat include: float plane activity, motorized and non-motorized use in both the summer and winter on and off existing trails by hikers, snowmachiners, hunters, and flight see-ers. Also affecting habitat are Forest Service trail systems and associated infrastructures, private residences, businesses along the Seward and Sterling Highways, and utility and telephone corridors adjacent to the highway.

Heritage Resources

Prehistoric Period. Archeological and ethnographic data have documented prehistoric use on the Seward Ranger District in the Early to mid-Holocene (10,000 to 3,000 before present [BP]), the Riverine Kachemak (3,000 to 1,000BP) and the Late Prehistoric (1,000 to 200BP) periods. The Late Prehistoric is associated with the Dena'ina culture, who constructed villages containing large multi-family houses and underground cache pits for cold storage (Boraas 2002). The Dena'ina (Kenaitze Indian Tribe) still reside and are active on the Kenai Peninsula today.

The prehistoric use of the Quartz Creek drainage is represented by three sites identified with a prehistoric component. These include SEW-00186, SEW-00187, and SEW-00611. Adjacent to, and to the west of, the landscape assessment area is the Squilantnu Archaeological District (SEW-00282), which is eligible for the National Register. It is associated with prehistoric use of the salmon runs along the Kenai River and Russian River. Other prehistoric sites may occur in the Quartz Creek drainage, associated with prehistoric use of salmon runs. High-altitude sites associated with seasonal sheep, goat, or caribou hunting may also exist. One high-altitude housepit site has been inventoried adjacent to, and west of, the landscape assessment area on Falls Creek. The data suggest that while activity may have been concentrated along streams with salmon runs, dispersed activities may also have taken place in high-altitude environments and in areas of high-relief.

Historic Period. The Russians staked their claim on Alaska in the mid 18th Century, after the voyages of Gvozdev and Bering in 1732 and 1741, respectively (Black 2004, page xiii). They occupied parts of Alaska until 1867, and while they had substantial effects on certain Native Alaskan populations, including those of the Aleutian Islands, Kodiak, and Southeast, they had little direct effect on the Dena'ina settlements in the northern and eastern Kenai Peninsula and interior of the Peninsula. A skirmish between Dena'ina and Russians at Point Possession and Doroshin's 1840 ascent of the Kenai are the only well-defined penetrations of the eastern Kenai Peninsula Dena'ina country. Doroshin travelled up the Kenai prospecting for mineral deposits on Cooper Creek and Kenai Lake.

Joseph Cooper, of Kachemak Bay, reported finding gold on Cooper Creek in 1884. In 1880 or 1888, Alexander King, a native of Ohio, who had experience in prospecting and mining from time spent in the goldfields of California, discovered gold on Resurrection Creek (Tuck 1933, page 521). In 1888 Charles Miller staked the first claim on Resurrection Creek, 2 miles upstream from Hope. The discovery of gold on the east side of the mouth of Sixmile Creek in 1888, and at Bear Creek and Palmer Creek in 1894 (Tuck 1933, page 521), would lead to the location of claims on Mills, Canyon, and Lynx creeks in 1895 as the "first trickle of gold seekers came into Turnagain Arm from the Outside" (Barry 1997 [1973], page 34).

The gold rush to the Turngain Arm in 1895–1896 would transform the towns of Sunrise and Hope. Hope is located at the mouth of Resurrection Creek, and served the needs of the miners on this creek. During 1895, it grew from 10 to 12 log cabins to around 30 log cabins and numerous tents; the population of the town was approximately 400 men by the early summer; the presence of women at that time is not quantified (Barry 1997 [1973], page 34). This particular gold rush was dominated by prospectors and miners from other Alaskan mining districts, with some outsiders coming fresh from the mainland United States (Barry 1997 [1973], page 38). By mid-May 1896, Hope would grow still further, with over 2,000 people coming to the Turnagain Arm, two-thirds of whom went to Resurrection Creek and Hope (Barry 1997 [1973], page 52-53). The year of 1896 was the "banner year on Canyon Creek, [with] 327 men being engaged in mining the gravels during the summer" (Moffit 1906, page 9). Fewer people would travel to the Turnagain Arm in 1897 than in the preceding year, partly as the result of the Klondike strike in the Yukon, Canada (Barry 1997 [1973], page 71). There would be a second rush to the Turnagain Arm in 1898; however, this influx of gold-seekers was much smaller than the rush of 1895–1896.

The gold rush period is not represented by any particular sites on the Quartz Creek drainage, though activities during this period may have contributed to the features currently inventoried. Much of the mining during the gold rush period consisted of pick and shovel operations, which leave only a very faint archaeological presence.

After the gold rushes subsided, considerable prospecting and mining continued to take place on the eastern Kenai Peninsula, including along the Quartz Creek drainage. It was at this time, between approximately 1900 and the 1930s that capital-intensive placer mining began in the form of many hydraulic mining operations. This period also saw the beginnings of lode mining at several locations on the eastern Kenai Peninsula, including Slate and Summit Creeks. In addition, Cooper Landing, a settlement that stretches along the Kenai River, was founded during this period.

The post-gold rush period is represented by almost all of the historic sites within the landscape assessment area. Noteworthy sites include the Gilpatrick Dike Mine District (SEW-00952) and the Moose Pass Military Road (SEW-00573). Most of the historic sites in the landscape assessment area are associated with historic mining. Other activities would have occurred as well, however, including tie-hacking (for railroad ties), hunting, fishing, and trapping.

Present Day Use. During the latter part of the twentieth century, the importance of mining and timber-related industries have diminished. Recreation and tourism, including guided and non-guided hunting and fishing, have come to supplant these industries, and have continued into the present. Mining has continued, but most mining is now small operations using low-impact suction dredges, rather than the large operations and impacts of the past.

Cooper Landing was at the time of the 2000 census a town of 269 residents. A seasonal population adds to this number during the warm summer months during which most tourism and guided recreation is concentrated.

Recreation

Recreation use of the Quartz Creek Watershed is concentrated along two main highways and several miles of secondary roads. Most of the developed recreation sites are accessible by road, except for two cabins. The amount of recreation use diminishes with increasing distance from access routes. Although there is less use further from roads, those who are using these more remote areas have expended much more in time, energy, and/or money than those who are recreating closer to the roads. Approximately 42 percent of the Quartz Creek Watershed area is in the backcountry management area in the Forest Plan, which is managed to emphasize a variety of recreational opportunities in natural appearing landscapes or other prescriptions. Of the remaining lands, all are in management areas where recreation use is emphasized, generally at a more developed level. Tourism is expected to grow in Alaska and accounts for a significant amount of recreation use in the Quartz Creek Watershed area, especially in the summer. This growth will add more demand for all types of summer recreation opportunities, but especially to those areas already most heavily used.

Summer Recreation. The most constant human presence within the analysis area is likely to occur during the summer months (approximately June through September). However, the majority of this activity is restricted to within a short distance of the Seward and Sterling Highways, generally termed “front-country,” as dense vegetation and rugged terrain features make much of the area inaccessible to the majority of recreational users. Additional summer access is possible for float plane-based recreationists along the lakes within the watershed.

Winter Recreation. Winter season (approximately December through April) supports the farthest-reaching recreation as deep snow and frozen bodies of water allow easier access into backcountry areas. Winter recreation within the analysis area includes, snowmachining, firewood collecting, cross country skiing, backcountry skiing and snowboarding, and snow shoeing. This dispersed recreation has the greatest potential to reach remote areas of the analysis area and potentially overlap with important biological habitats. This is especially true of winter motorized recreation. Snow machines are able to travel dozens of miles into backcountry from road access points along the Seward and Sterling Highways. There is also an unknown amount of private aircraft use and air-taxi services transporting individuals into backcountry locations during winter months.

The amount of recreation use in the Quartz Creek Watershed is moderately high relative to other areas on the Seward Ranger District, due to easy access from the highway and recreation sites near lakes and rivers. The majority of the recreation use in the Quartz Creek Watershed occurs during the summer months (June through August) and coincides with the arrival of seasonal summer tourists; however, snow machine use and cross country skiing also occur along the Quartz Creek corridor and trails.

The recreation activities taking place in the Quartz Creek Watershed are hiking, fishing, fly-in fishing, hunting, trapping, mountain biking, horseback riding, camping, backcountry cabin use, boating, nature photography, wildlife viewing, outfitter and guide use, dog sledding, firewood collecting, berry picking, relaxation with families and friends, ice skating, cross-country skiing, and snow-machining. Existing recreational facilities in the Quartz Creek Watershed include the following: Quartz Creek Campground and Day Use Area, Quartz Creek Beach, Crescent Creek Campground and Day Use Area, Tern Lake Day Use Area, Carter Lake Trail, Crescent Creek Trail, Crescent Lake Trail, Devils Pass Trail, Slate Creek Trail, Summit Creek Trail, Old Sterling Highway Trail; two backcountry cabins; and at least four designated dispersed camping sites.

Moose Pass and Cooper Landing communities are located adjacent to the Quartz Creek Watershed. Moose Pass is located at mile 29 of the Seward Highway (an All-American Road and National Forest Scenic Highway) in the eastern part of this watershed. Cooper Landing is located at mile 47 of the Sterling Highway near the western part of the Quartz Creek Watershed. Anchorage, Alaska's largest population center, is located approximately 100 miles north (by car) of the Quartz Creek Watershed.

3. Key Issues and Questions

The following issues and key questions are important for management of the Quartz Creek Watershed and provide a framework for the landscape assessment. Some of these questions address natural processes that provide a basis for evaluating other issues. Others are important management considerations and should be evaluated by a variety of resource specialists.

Lands

Questions:

- What is the land ownership in the area (Federal and non-federal)?
- What property rights do third parties hold in the area on Forest Service lands (i.e., easements held by the borough, etc.)?
- What property rights are held by the Forest Service on non-Forest Service lands?
- What public land orders exist in the area and when do they expire?

Geology, Minerals and Soils

Geology and Minerals

Question:

- What is the likelihood or additional mineral development in the Quartz Creek Watershed?

Soils

Issue: Surface soil erosion will occur anywhere the mineral soil is exposed to water drop splash and runoff. Most often, it is not a major concern until significant rills or gullies are formed indicating a large amount of soil is being transported, thereby decreasing soil productivity. If this sediment reaches a stream, especially a fish stream, it then becomes a higher priority to reduce or eliminate the sedimentation. Proposed development of trails, roads, and fuel reduction projects all have the potential to expose the mineral soil and cause erosion.

Hydrology

Issue: Human uses along stream channels in the Quartz Creek Watershed are causing bank erosion, stream channel changes, and water quality impacts. These impacts are most pronounced as a result of recreational uses and development along the lower portion of Quartz Creek. Other impacts to streams from human uses in the watershed include localized impacts resulting from trails, roads, and mining activities.

Questions:

- What are the impacts of human uses on bank condition along lower Quartz Creek?
- What is the impact of the Crescent Creek Road Bridge on channel processes on Quartz Creek?
- What are the impacts of human uses along Tern Lake and Daves Creek?

- What are the impacts of existing placer mining operations on stream channels in the watershed?
- What are the impacts on water quality from roads and developments in the watershed?

Issue: The Daves Creek Stream Restoration Project is being implemented in 2009 and 2010 to restore a section of Daves Creek that was impacted by highway construction in the 1960s. The success and outcome of this project on restoring the natural stream channel and riparian conditions will be determined through post-implementation monitoring over the next 10 years. Channel processes, riparian regeneration, bank stability, habitat, aquatic populations, and future impacts from human uses will be evaluated.

Question:

- How well has the Daves Creek Stream Restoration Project achieved its short- and long-term objectives?

Issue: Naturally dynamic streams in the watershed can potentially impact established recreational sites and other developments in the watershed.

Question:

- How are natural channel changes in Upper Daves Creek and Quartz Creek affecting the Tern Lake Day Use Area and the Quartz Creek Campground?

Issue: Climate change on the Kenai Peninsula is likely to cause gradual changes in precipitation patterns, flood dynamics, and vegetation conditions, potentially affecting stream channel conditions, stream processes, and riparian composition. These potential long-term changes are not well understood at this time, but will likely be a factor in resource management in the future.

Question:

- How are climatic trends affecting glaciers, stream flows, channel morphology, and water quality in the Quartz Creek Watershed?

Vegetation and Ecology

Questions:

- What are the major succession processes or disturbance regimes at work on the landscape?
- How are insects and diseases impacting the landscape?
- What is the current status of vegetation in relation to historic range of variability for the Quartz Creek area?

Botany and Weeds

Issue: Management activities, recreation, and other human uses may affect rare plants or their habitat.

Question:

- How will current and predicted human use, activities, and infrastructure affect sensitive plant populations?

Issue: Climate change and natural processes may affect rare plants or their habitat.

Questions:

- Is climate change or natural processes affecting sensitive species or their habitat?
- What effects will large fires have on sensitive plant species or their habitat?
- Are management actions needed to protect or monitor the effects of these changes?

Issue: Natural disturbance and human use may increase ground disturbance and the potential for establishment and spread of nonnative species.

Questions:

- How will current and future human use, activities, and infrastructure increase the population and spread of nonnative plant species in the Quartz Creek area?
- What impacts will nonnative plant species have on natural ecosystems?
- What impacts will large or widespread wildfires have on populations of nonnative plants?
- Is the current inventory and treatment plan for nonnative plants adequate given the likelihood of increased establishment and spread in the future?
- Are there opportunities for partnerships to promote management of nonnative invasive species in the Quartz Creek area?

Fire and Fuels

Issue: Spruce bark beetle infestation in the watershed may result in an increased risk of natural or human-caused wildfire, with associated degradation of air quality.

Questions:

- Will increased recreation use bring the likelihood of more human-caused fires?
- Will the spruce bark beetle outbreak in the area, along with increased recreation use, increase the threat of wildfire impacting the campground and homes in the area due to unwanted ignitions?

Issue: Smoke related impacts to air quality and visibility.

Aquatic Species and Habitats

Questions:

- What impacts will current and future land management and development have on water quality; aquatic habitat; and populations of salmon, rainbow trout, Dolly Varden, and other aquatic species within the watershed?
- What impacts will current and future angling pressure have on riparian areas; stream morphology; aquatic habitat; and populations of salmon, rainbow trout, Dolly Varden, and other aquatic species within the watershed?
- What impacts will introduced/stocked triploid rainbow trout and potential introduced disease such as whirling disease and bacterial kidney disease have on populations of salmon, rainbow trout, Dolly Varden, macro-invertebrates, and other aquatic species within the watershed?
- What is the occurrence of invasive species such as northern pike, Atlantic salmon, and New Zealand mud snails within the watershed?

- What impacts will noxious weeds and other invasive plant and animal species have on riparian areas; stream morphology; populations of salmon, rainbow trout, Dolly Varden, macro-invertebrates and other aquatic species within the watershed?
- What effect has the road and trail network had on stream morphology, fish passage, and aquatic organism access to off-channel habitat?
- What effect has large-scale stand-replacement fires and increased fire frequency due to human causes had on riparian vegetation, in-stream large woody debris levels, and habitat complexity?
- What effect will the infestations of spruce bark beetles and climate change have on fire frequency, riparian vegetation, in-stream large woody debris levels, and habitat complexity?
- What effect has historic mining had on stream channel morphology, riparian vegetation, and aquatic habitat?
- What effect will future mining have on stream channel morphology, riparian vegetation, and aquatic habitat?
- Is a comprehensive watershed restoration analysis and strategy needed to prioritize restoration projects and funds?

Terrestrial Species and Habitats

Questions:

- How are human uses (recreation, roads, development) affecting brown bears in the watershed and the brown bear core area?
- How many brown bears inhabit the watershed?
- How are hiking, fishing, flight seeing, and other recreation activities affecting brown bears in the watershed and in the brown bear core area.
- How are roads affecting habitat connectivity?
- Have there been documented bear/human encounters or DLPs (defense of life or property), and if so, are the trends increasing?
- How are human uses (recreation, roads, development, subsistence) affecting management indicator species (MIS) and species of special interest (SSI)? Are wildlife species or their habitat needs coming into conflict with human uses, or human uses impacting wildlife or their habitats?
- How has the spruce bark beetle infestation affected the habitat, abundance, or distribution of MIS and SSI species?
- What is the distribution and abundance of key habitat components such as old growth, hardwood browse, thermal and hiding cover, snags, downed logs, and travel corridors?
- What are the effects of climate change on MIS and SSI species?

Heritage

Issue: Approximately 99 percent of the Quartz Creek drainage is unsurveyed for cultural resources.

Issue: Most of the sites identified have not been evaluated for National Register eligibility.

Issue: Predictive model (how we determine where we survey) is biased towards existing project areas in the valley bottoms and along modern trails and roads.

Questions:

- Where are impacts to National Register eligible cultural resources occurring?
- Where might we reasonably foresee further impacts to occur in the future?
- Do the areas of impacts (current or future) coincide with areas that have been surveyed for cultural resources?
- What is the potential for properties that can help interpret the area's prehistoric and historic cultural heritage to the public?
- What is the level of interpretation of cultural resources or traditional cultural activities actually desired by the district?
- Are there any places where interpretations of cultural resources or traditional cultural activities can "piggy-back" on interpretation of other resources, or the other way around?
- How is recreation (both guided and unguided) affecting cultural resources in the landscape assessment area?
- What potential opportunities for partnership to help fulfill heritage program goals (monitoring, interpretation, inventory) can be identified in the landscape assessment area?
- What impact has climate change had, or might have in the future, on the condition of potential perishable cultural resources in snow at high altitudes within the landscape assessment area?

Recreation

Issue: There is a need for recreation use data (numbers and types of users across the watershed).

Question:

- How much and what type of public use exists in the Quartz Creek Watershed?

Issue: Recreation development (trails, cabins, etc.) may adversely affect other forest resources, such as vegetation, soils, streams, and wildlife.

Questions:

- Should there be an increase or decrease in commercially guided opportunities in the watershed?
- Is the existing recreation development sufficient to meet the recreation demand of the public for the Quartz Creek Watershed?

Issue: Participation increases in recreation activities and types of activities may lead to increased user conflicts.

Questions:

- Has an increased demand for dispersed fishing opportunities (commercial and non-commercial) increased impacts (biophysical) in the Quartz Creek riparian area and increased social conflicts?

- Will further recreation development or lack of development in the Quartz Creek Watershed increase user conflicts between anglers, hikers, bikers, equestrians, and other visitors?

4. Current Conditions

This portion of the landscape assessment discusses the current range, distribution, and condition of resources within the Quartz Creek Watershed, and provides a summary of all information relevant to the issues and key questions known about the watershed.

Lands

The following public land orders, easements, State of Alaska and private property exist within the landscape assessment area.

Public Land Orders

PLO 829, dated May 16, 1952, reserved 180 acres west and south of Tern Lake for use as a recreation area, administrative site, or other public purposes. This area is withdrawn from mineral entry and encompasses the Tern Lake Picnic Area and former campground, and south of Summit Lake.

PLO 1731, dated September 17, 1958, reserved 130 acres north of Tern Lake for use as a recreation area or administrative site. This area is withdrawn from mineral entry and encompasses the triangular junction of the two highways.

Easements

A highway easement deed, dated October 1978, grants the State of Alaska Department of Transportation a 200-foot-wide right-of-way for highway purposes (100 feet each side of the centerline).

A right-of-way for the old Sterling Highway (Forest Road 961) was reserved to the United States when the land transferred to the State in T5N, R2W, sections 15 and 16 (Quartz Creek [1995]) and Quartz Creek Addition [1992] State selections). The width of the right-of-way in section 15 is 66 feet. In section 16, the width is unspecified. A 3-acre site easement for the Crescent Creek Trailhead and a 50-foot-wide trail right-of-way for the Crescent Creek Trail were reserved to the United States when Cooper Landing selection transferred to the State of Alaska in 1983. The United States holds no additional reservations on the remaining portions of the old Sterling Highway from Tern Lake to Quartz Creek Road (sections 20 and 29).

Private and Other Non-Forest Service Property

Please see figure 2 for a location map of private and other non-Forest Service property.

Geology, Minerals, and Soils

Geology and Minerals

Minerals

There are numerous mining claims throughout the Quartz Creek Watershed, covering 1,650 acres, or 2.2 percent of the watershed. Most of the mining claims are along Devils Creek, upper Quartz Creek, Crescent Creek, Slate Creek, and Summit Creek. These include both placer mine and hard rock mine claims. Thirty-one mine sites, including placer mines, underground mines, and prospects, are located within the watershed. Most of these mines are within 1 mile of the highway corridors. The primary mineral of interest at these mines is gold; although silver, copper, and stone are also mined (MacFarlane 2008).

Gravel has been mined from at least two locations in the watershed. The gravel pit along the Sterling Highway at the Quartz Creek Bridge was mined during construction of the highway in the 1940s. This pit is now a pond along Quartz Creek. A gravel pit was also mined on the south side of the Upper Quartz Creek alluvial fan, on the east side of the Seward Highway north of Johns Creek. This gravel pit is on State land and remains active (MacFarlane 2008).

Soils

While landslides are a significant feature and hazard on the Forest and the Kenai Peninsula, no natural or management-caused slope failures are mapped in the land system inventory coverage for the Quartz Creek Watershed. In addition to landslides, glaciers are the most significant landscape feature on the Forest and the Peninsula, but only between 35 and 360 acres of glacier remain and are mapped within the watershed, depending on the data layer referenced. Landslides may be inconsequential in this landscape; therefore, the overall weathering rate and glacial recession are having the most effect on the geomorphic surface and soil development in the assessment area.

There are several glaciers within the assessment area that have receded or are receding (see figure 4). As glaciers recede, the area of land where soil is beginning to develop is increasing. Recently exposed glacial surfaces may have a head-start on soil development compared to some other recent surfaces; for example, volcanic flows, depending on the glacial history and parent material. Even though the surface is ice-free in these areas, fundamental soil ecosystem processes are in a rudimentary stage if the geomorphic surface is less than about 10-years old. Over the next decade to about 150 years, identifiable soil processes are initiated and process rates increase to measurable levels. These processes include: changing of the below-ground temperature regime, chemical weathering and precipitation of soil minerals, colonization by bryophytes and early successional vascular plants, increasing chemical complexity, colonization and increasing complexity of soil wildlife and floral communities, and accumulation and transformation of soil organic carbon, among others. After the basic soil system components are established, nitrogen, carbon and other cycling reach a stage where they are functionally stable. Higher plant communities including trees and shrubs establish and develop, further increasing organic matter accumulation. By this time (after approximately 10 to 150 years depending on initial conditions), soil changes are fairly dramatic. Soil bulk density has decreased by 60 percent or more, pH has decreased from near neutral or higher to about 6 or lower as the result of weathering, and pedogenic horizonization has progressed to the degree that the soil classification will change from its original “entisol” condition, and after an additional similar time period, the soil changes would likely cause classification to change again. Along with these changes, soil characteristics, behavior, and responses to disturbance also change. For a complete review of soil development and surface age following glaciation, see for example, Crocker and Major (1952); Tisdale et al. (1966); and Yoshitake et al. (2005).

Since the mid-1950s, the average glacial recession of 67 glaciers in Alaska, including some on the Kenai Peninsula has been 1.8 meters per year (Arendt et al. 2002). There can be some ponding of melt water below the glacial front, for example the lake below Trail Glacier, but there is generally rock, rock debris, and rock flour exposed. The Arendt recession rate equates to an average of about 90 meters of newly exposed surface for each glacier in the Peninsula, including the assessment area, ranging in age from the present to 50-years old.

Natural soil erosion rates vary largely by soil type, slope, mulch or litter cover, and climate. Current conditions for landslides at the landtype scale have been discussed earlier. Typically, baseline erosion is within the range of about 0.1 to 0.001 tons per acre per year. Accelerated erosion from timber harvest-vegetation treatment, construction, severe wildfire, livestock grazing, or intensive agriculture can be over 800 tons per year. Within the Quartz Creek Watershed, undisturbed, natural conditions produce only a baseline soil erosion rate.

Recent management activities that have or could disturb the soil cover and accelerate erosion affect several hundred acres in the assessment area, and include roads and trails on Forest and other ownerships. About 235 acres of the proposed Tern Lake Fuel Reduction Project would occur in the Quartz Creek Watershed. This project would have no measureable effect on soil properties. There were timber sales in the 1980s, but no GIS coverage or other mineable data includes information about them or the area involved. If they involved skidding and skid trail or road construction, they had and may have effects that persist, but are unknown at the time of this report. Past prescribed fires likely had or have little effect, as is the case with most prescribed fires in this part of Alaska, which are light. Other recent or proposed projects such as community wildfire protection plans are expected to have similar effects as the Tern Lake Fuel Reduction Project; likewise with “wildlife habitat improvement” projects that manipulate vegetation. Quartz Creek and Crescent Creek Campgrounds affect soil quality and productivity similar to roads and trails. Erosion control and revegetation has taken place over time and soil that is currently not disturbed by pavement is stable. The Daves Creek Stream Restoration project has disturbance effects including displacement and erosion that will be remediated or restored by 2010 or 2011 at the latest. Kenai winter access effects on soil stability or productivity occur through road corridors, such as snowmobile parking lots, which permanently affect soil productivity, but are stable.

Hydrology

Climate

The climate of the Kenai Peninsula has been warming over at least the last several decades, a trend that is consistent with much of Alaska and other areas worldwide. Between 1949 and 2008, the mean annual temperature has increased by 3.1 degrees F in Anchorage, and 3.9 degrees F in Homer, with an average 3.1 degree increase Statewide (Alaska Climate Research Center 2009). Based on these datasets, it is likely that the mean annual temperatures in the Quartz Creek Watershed have increased by 3 to 4 degrees F. The largest seasonal temperature increases are the winter temperatures. Over the same time period, average winter temperatures have increased 6.3 degrees F in Homer, 6.8 degrees F in Anchorage, and 6.0 degrees F statewide (Alaska Climate Research Center 2009). Data compiled from the weather station at Moose Pass from 1967 to 2003 (Western Regional Climate Center 2009) echo these trends, with steadily increasing mean annual temperatures and large increases in the average January temperature (figure 13). It is expected that this trend of increasing temperature will continue.

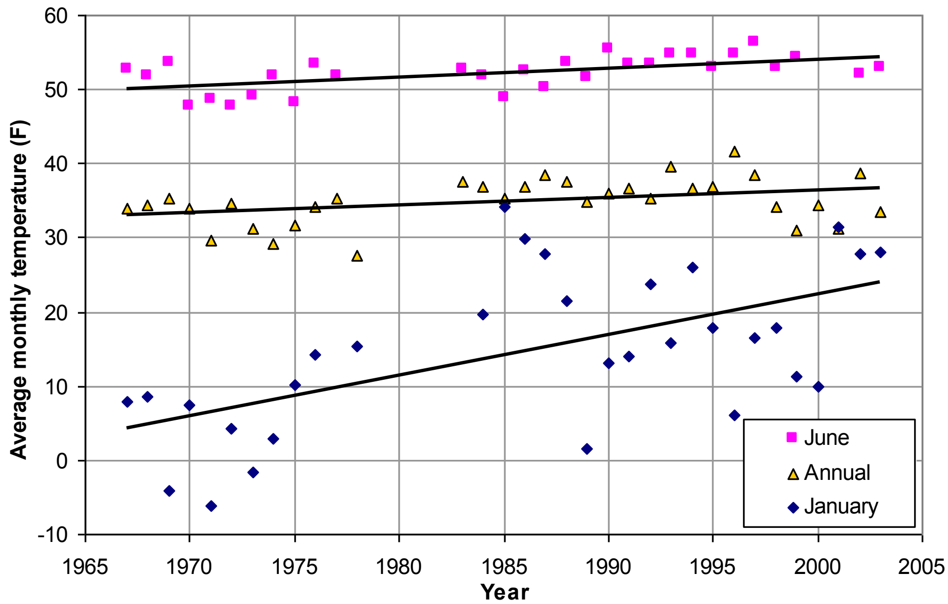

Figure 13. Average monthly and annual temperatures, 1967 to 2003, for Moose Pass, Alaska (Station #505894; data from Western Regional Climate Center [2009])

The effects of climate change on water resources in the Quartz Creek Watershed are not easily quantified, and data are not available to quantify changes in hydrology. However, climate change has and will continue to have effects on the hydrology of the watershed. Climatic changes may result in hydrologic changes including glacial melting, increased peak flows, increased flooding related to rain-on-snow events, and changes in infiltration or evapotranspiration rates as a result of vegetative changes. Changes in water quantity will be difficult to quantify in the watershed, as no stream gauges are currently in operation. Increased drought conditions can also lead to further spruce bark beetle infestation. Although the bark beetle does not generally have a large effect on evapotranspiration rates or streamflows, increased amounts of dead spruce along Quartz Creek can lead to increased quantities of woody debris in the channel.

Stream Channel

Stream channels in the majority of the watershed are un-impacted by human uses and are in their natural conditions, because much of the watershed is relatively inaccessible backcountry. Stream channels that are impacted by human uses are generally within 0.25 mile of a road or campground. Because fishing regulations currently prohibit salmon fishing in the watershed, bank degradation from angler trampling is considerably less severe than along salmon fishing streams such as the Russian River.

Quartz Creek. The lower 6 miles of Quartz Creek, from the Sterling Highway Bridge to Kenai Lake, is characterized by meandering channels and dynamic changes. Channel migration in this reach has occurred naturally over the past hundreds of years. With retreat of the glaciers in the Holocene, sediment supply into this reach decreased and the previously braided channel transformed into a single meandering channel. Also, as a result of the decreased sediment load, the existing channel downcut over time, leaving terraces where the old outwash surfaces existed and building new floodplains in the meander belt width. The history of channel migration in this reach has left a floodplain landscape characterized by abandoned oxbows and meander scars.

Large woody debris is often prevalent in these areas, as easily erodible unconsolidated gravel banks are eroding and floodplain vegetation is entering the system from the banks. New point bars and floodplains that are developing are quickly established with alder and willow vegetation.

Dynamic channel changes in the lower 0.5 mile of Quartz Creek can affect and are affected by developments such as the Quartz Creek Campground and the Crescent Creek Road Bridge. Meander bends have migrated as much as 150 feet between 1961 and 2000 (figure 14). Two channel avulsions have also occurred between 1961 and 2000, where tight meander bends were cut off. This channel will probably continue to migrate at these meander bends, with a strong possibility of future channel avulsions. Upstream and downstream of the Crescent Creek Road bridge, the radii of curvature of the meander bends are decreasing, but the presence of the road and the location of the bridge has prevented channel avulsion from occurring across the road. This has caused the channel to flow along the road in two places, causing erosion to the road bed. The meander bend upstream of the bridge is currently starting to cut through the alders on the point bar. The meander bend downstream of the bridge may experience avulsion in the near future, as high flows are starting to create channels across the neck of the meander bend. Channel avulsion at this location would result in additional channel changes downstream.

The Quartz Creek Campground is somewhat protected from the migrating channel. The area in which a 350-foot boardwalk was recently constructed along the channel has remained relatively stable over the past 40 years (figure 14). However, angler trampling along the banks of Quartz Creek contributes to bank erosion and increasing rates of channel migration (photos 1 and 2). The Forest Service, in cooperation with the Youth Restoration Corps, has conducted bank restoration work on Quartz Creek in two sections where angler trampling has damaged the banks just downstream of the Crescent Creek Road Bridge and near the campground (figure 14). Also, the Forest Service established eight permanent cross sections on this reach of Quartz Creek in 2002 as baseline surveys to study flow hydraulics and channel dynamics (figure 14).

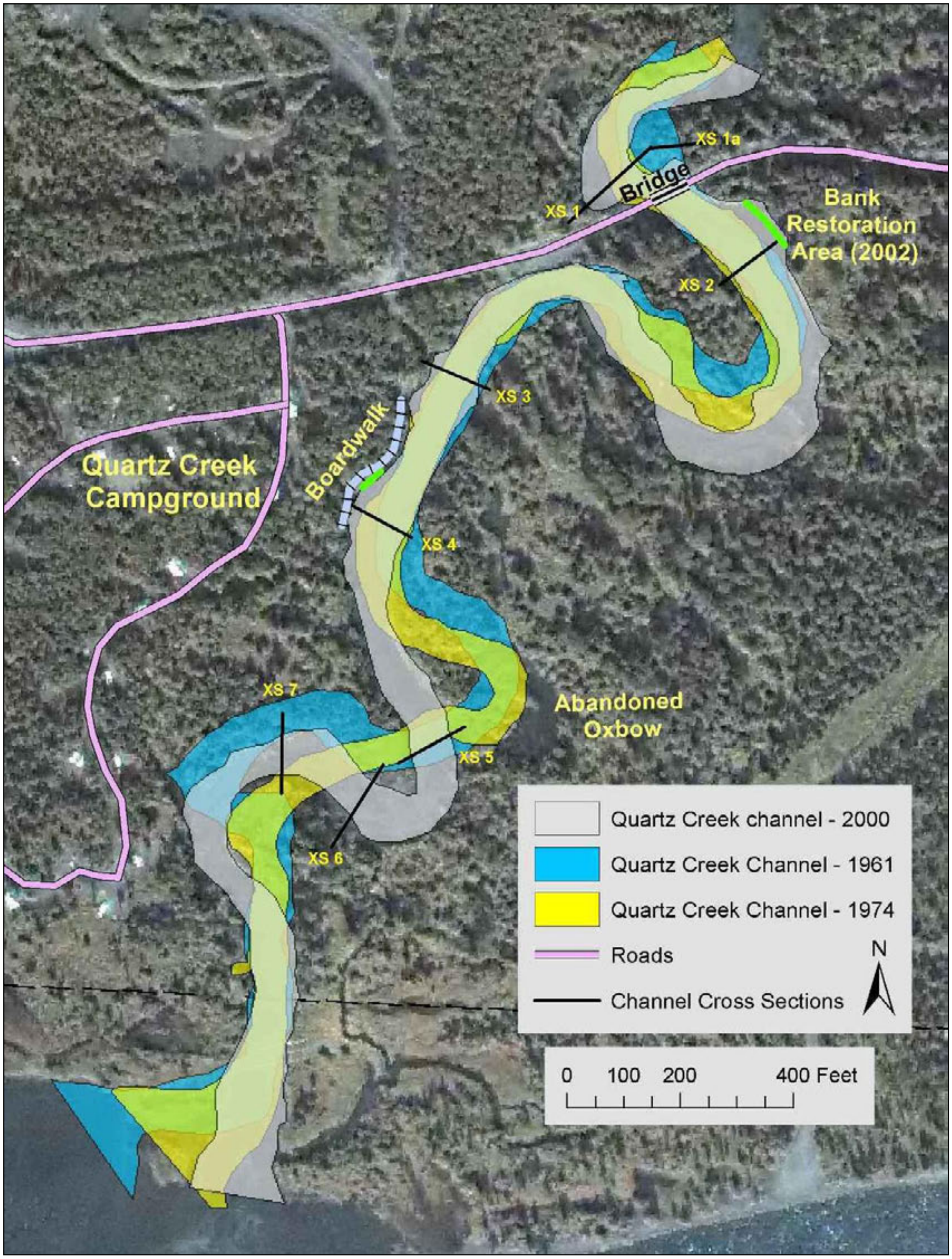

Figure 14. Channel changes on lower Quartz Creek from 1961 to 2000 (base photo is from 2000)

Photos 1 and 2: Eroding bank along lower Quartz Creek near Quartz Creek Campground (left); and willows growing on restored bank downstream of Crescent Creek Road Bridge (right) (May 2007)

Tern Lake and Daves Creek: Tern Lake drains 9.5 square miles. Much of the area drains steep mountain slopes, including a small glacial remnant at the head of "Upper" Daves Creek, which flows north into Tern Lake. The small 2.1-square-mile Upper Daves Creek drainage produces abundant sediment and has developed an alluvial fan over the past 14,000 years that has effectively dammed the valley floor and created the shallow Tern Lake (figure 15).

Daves Creek originates at the Tern Lake outlet and flows into Quartz Creek. The original course of the Sterling Highway included a bridge crossing the Tern Lake outlet. The highway was reconstructed in the 1940s on the north side of Daves Creek, and in the late 1960s, the Tern Lake outlet was put into a 42-foot-long, 8-foot-wide culvert under the access road to the new Forest Service campground at Tern Lake (Bair et al. 2006). The culvert at the outlet maintained the elevation of the lake outlet. Installation of the culvert also reduced the conveyance capacity of water at the outlet, causing greater increases in the lake elevation during floods than occurred previously with the bridge in place (Blanchet 2003). This was raised as a concern by residents of "Avalanche Acres" east of Tern Lake. Infilling and eutrophication in Tern Lake have caused the lake to shrink in size and depth over the past century, but analysis of aerial photography back to the 1950s shows little change in the size and shape of the lake since then.

Daves Creek initially ran a sinuous course across the valley floor in the first mile downstream of Tern Lake between the alluvial fan and the northern side of the valley. During construction of the Sterling Highway in the 1940s, Daves Creek was moved into a constructed channel along the south side of the highway just downstream of the Tern Lake outlet (figure 15). The result was a 1,500-foot reach characterized by a narrow, ditch-like channel with little sinuosity and poor connectivity with its floodplain, unhealthy banks, and few beneficial habitat features. In the 1980s, the Forest Service placed three full-span, 1- to 2-foot-high log weirs in the 300 feet immediately downstream of the culvert to provide habitat features (photo 3). However, placement of the log weirs resulted in channel widening at the weirs and hampered fish passage. Further impairment of the 1,500-foot reach downstream of the Tern Lake outlet was caused by additional channel encroachment from highway widening projects (photo 4) and the input of winter sanding gravel, trash, and other pollutants into the channel from the adjacent highway.

Daves Creek Stream Restoration Project: Channel restoration of the Tern Lake outlet and the 1,500-foot reach of Daves Creek downstream of the outlet began in 2009 (figure 15, photos 5 and 6). Project details are provided in the "Daves Creek Watershed Restoration Plan" (Bair et al. 2008) and the environmental assessment for the project (USDA Forest Service 2008). The culvert was replaced with a 40-foot-long glu-lam bridge, greatly increasing the flow capacity out of Tern Lake while maintaining the normal lake elevation. The gradient at the outlet was decreased to allow fish passage into Tern Lake. The log weir structures were reconstructed as riffles to provide more natural channel morphology. The ditch-like channel was reconstructed further from the highway, with pool-riffle morphology, increased sinuosity, large woody debris, and habitat structures. Floodplains were constructed and covered with soil from the project area to promote natural re-vegetation in the 10-acre project area. Restoration construction is scheduled to be completed by July 2010. Re-vegetation of the floodplains will occur in 2010, and monitoring of channel morphology, vegetation, aquatic habitat, and fish populations will occur from 2010 to 2018.

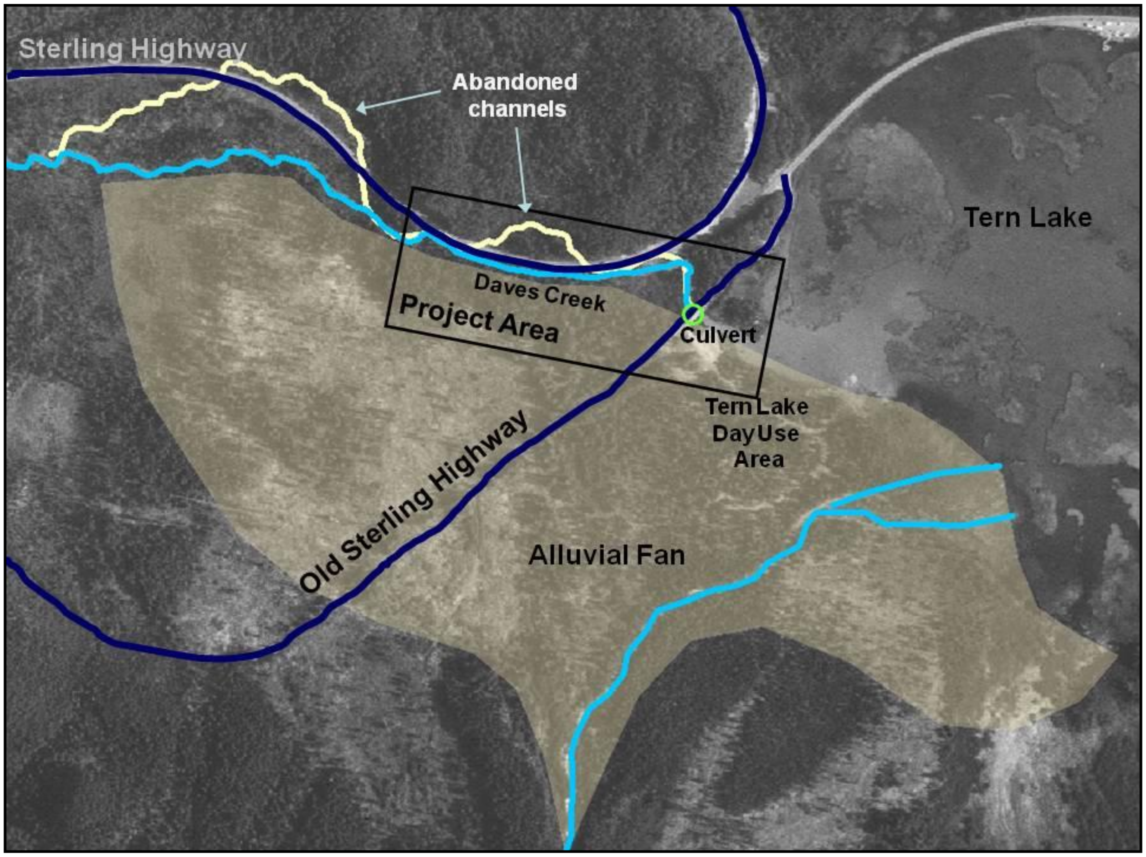

Figure 15. Tern Lake, Upper Daves Creek alluvial fan, and Daves Creek, prior to the 2009–2010 Daves Creek Stream Restoration Project


Photos 3 and 4: Daves Creek downstream of Tern Lake prior to 2009 restoration (April 2007); log weir in the structure reach (left); ditch-like reach along the Sterling Highway (upper right)


Photos 5 and 6: The Daves Creek channel was reconstructed further from the highway during 2009 restoration (left); and the new Tern Lake outlet bridge after 2009 restoration (right)

Upper Daves Creek: Over geologic history, Upper Daves Creek has migrated across its alluvial fan as additional sediment is deposited on the fan. Although this process of sediment deposition on the alluvial fan continues, the Upper Daves Creek channel has remained on the east side of the fan for at least the past 60 years. It is possible that at some point in the future, Upper Daves Creek could migrate by natural processes to the west side of the fan and completely bypass Tern Lake, reducing the inflow and outflow of the lake, reducing the depth of the lake, and significantly reducing the amount of flow in a portion of Daves Creek.

Since construction of the campground and day use area at Tern Lake, Upper Daves Creek has experienced some dynamic channel changes, at times threatening to carve a new channel through the day use area. A gravel levee was constructed between Upper Daves Creek and the day use area to protect the development from flood flows or dynamic channel migration. Some damage to the old campground road has occurred from Upper Daves Creek flood flows in the past. Multiple channels exist in this area, and the flow tends to meander in response to adjustments related to sediment deposition and in-channel woody debris. The most vulnerable location for channel avulsion may be at the apex of the fan.

Other Stream Impacts: There are numerous small-scale placer mining operations within the watershed. The effects of these operations on stream channel morphology and water quality is not well documented. Recreational mining using gold panning and suction dredging methods generally has only small impacts on stream channels when done according to regulations. However, recreational miners often do not follow these regulations and mine into the banks, which can result in bank erosion, loss of riparian vegetation, channel widening, channel aggradation, and increased turbidities. Larger operations require an approved mining plan of operations through the Forest Service and must meet State water quality regulations. Impacts to streams and water quality from roads and ATV (all-terrain vehicle) trails accessing mining claims in the watershed are also not well documented. Mining activities are often associated with a variety of impacts to riparian areas and stream banks.

Vegetation and Ecology

To understand current conditions of the vegetation in the Quartz Creek Landscape Assessment Area, one must first understand the succession pathways and disturbance regimes of south-central Alaska.

Disturbance is defined as "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Helms 1998, page 49). Disturbance on the landscape is described by the amount of overstory removal. Major disturbance is described as stand-replacing disturbance, whereas minor disturbance leaves some remnant overstory trees (Oliver and Larson 1996). Both of these types of disturbance shape the landscape in the Quartz Creek drainage.

Avalanches, seasonal floods, wind events, and occasional fires could all be major disturbances in the Quartz Creek drainage. Following a major disturbance, the typical succession pathway in this area would be for hardwoods (birch, aspen, or cottonwood) to initiate the new stand, then Lutz spruce would typically begin growing in the understory. The hardwoods are fairly short-lived, and as they succumb to mortality, spruce becomes a dominant species in the forest canopy.

Spruce may remain as the dominant species in the canopy for a number of years, but when influenced by endemic levels of insects or disease, often the least vigorous trees succumb to mortality, which creates small gaps in the canopy. Hemlock generally grows beneath the spruce canopy and can persist in the understory for long periods of time until it is released by a gap created in the canopy. When the gap is created, the hemlock begins responding to the increase in light and will eventually grow to become a part of the canopy, and can become the dominant late-seral species. In some stands, however, edaphic and climatic conditions are such that late-seral species may never become dominant.

One of the most important disturbance agents causing a shift in canopy dominance from hardwoods to spruce is stem decay. "Stem decay fungi alter stand structure and composition and appear to be important factors in the transition of even-aged hardwood forests to mixed species forests. Bole breakage of hardwoods creates canopy openings, allowing release of understory conifers" (USDA Forest Service 2009, page 53).

Among the softwoods, the principal biotic disturbance agent continues to be the spruce bark beetle (*Dendroctonus rufipennis*) which affects spruce. Other biotic disturbance agents include other bark beetles, animals, people, various rots, and occasionally defoliators. These other biotic disturbance agents are a small contributor to change within stands of softwoods in this area.

Abiotic disturbance agents are constantly at work and affect a wide variety of stands. Avalanches generally follow avalanche chutes and act on a stand to maintain shrubs or early-seral hardwoods in a stand. Wind generally causes disturbance in mature stands. Fire generally has the most significant effect on spruce stands. Seasonal flooding may affect any stand.

Botany and Weeds

Sensitive Species. Potential habitat for sensitive species that occurs in the Quartz Creek Landscape Assessment area includes tundra and heath, snow melt areas, wet mossy depressions, alpine scree slopes, small streams, moist to mesic meadows, open forests, rock outcrops, sand and gravel outwash, gravel bars and river floodplains, dry open sites with tall shrubs in riparian areas, wet coniferous forests, old growth hemlock forests, and open water shores and boggy areas.

Currently only one sensitive species is known in the assessment area; however, the entire area has not been surveyed, so other sensitive species may occur. Pale poppy (*Papaver alboroseum* Hult.), the one sensitive plant known from the assessment area, occurs on slopes above Crescent Lake. The Alaska Natural Heritage Program (AKNHP) ranks pale poppy as G3G4S3 (rare, uncommon, and vulnerable to apparently secure globally, with cause for long-term concern and rare, uncommon, and vulnerable within Alaska). There are about 30 occurrences of the species in the AKNHP and University of Alaska databases (AKNHP 2009). The plant is documented on the CNF from the Glacier Ranger District in the upper Portage Valley, in the Seward Ranger District near Ptarmigan Lake, growing on a terminal moraine at Palmer Creek, near Kenai Lake and near Crescent Lake. Pale poppy grows in open, well-drained gravelly areas. The plant tends to be infrequent at scattered sites within its range (FNA 2009). It typically grows on bare gravel and may have been more common in habitats exposed by glacial retreat. One-time (as opposed to recurring) disturbance by human use may create habitat for the species. Examples include stabilized road sides, railroad track beds, and disturbed gravelly areas such as old gravel pits. Repeated disturbance, however, may affect the plant's ability to reproduce (Charnon 2007). Current disturbances that expose bare gravel appear to be adequate to provide habitat for this species. Invasive nonnative plants are flourishing in some areas of the plant's habitat and are shading out the poppies.

Three rare species tracked by the AKNHP (but not on the R10 Sensitive Species List) have been documented in the Quartz Creek Landscape Assessment area: *Festuca occidentalis* (western fescue), *Pedicularis macrodonta* (muskeg lousewort), and *Douglasia laevigata* (cliff dwarf-primrose). These species may no longer occur in the assessment area. *Festuca occidentalis* and *Pedicularis macrodonta* were last documented in 1978 and 1951. The other two species were last documented in 1987. It is not known if more recent surveys have been conducted.

Most of the assessment area has not been disturbed by human uses. Vegetation is currently largely influenced by natural processes such as avalanches, landslides, flooding, fire, and spruce bark beetle infestations. Although most habitats for sensitive species remain in a natural condition, some habitat types such as forests and tundra shows signs of changing, possibly as a result of global climate change. Forest fires and spruce bark beetle infestations have increased in recent years and may be outside the historic range of variation for the area (LaBau 2006; Klein et al. 2005; ACCS 2009; ACIAC 2008). On the Seward Peninsula, forests are invading tundra-dominated landscapes in some areas (Lloyd and Fastie 2003). Over time vegetation structure is expected to continue changing as temperature and precipitation patterns change and permafrost melts.

Invasive Plants. Alaska appears to be entering a period of increased introductions and establishment of nonnative species (Carlson and Shepard 2007). Between 1941 and 1968, an average of one nonnative plant species was established in the State annually. Between 1968 and 2006, that number increased to three per year (Carlson and Shepard 2007). Carlson and Shepard estimated that a total of 157 nonnative plant taxa have naturalized (i.e., formed self-perpetuating populations) in Alaska; an additional 136 nonnative taxa appear to be ephemeral (Carlson and Shepard 2007). Although the frequency and abundance of nonnative plants in Alaska are lower than in most other states, there is evidence that nonnatives are moving beyond the anthropogenic footprint into more intact ecosystems, often in habitats of natural disturbance (Carlson et al. 2008). Several species used in the past for roadside seeding now visually dominate sections of roadside and are moving into wetlands and riparian areas in parts of the State. Several species have recently spread into vulnerable natural disturbance areas adjacent to roads such as wildfire scars and glacial river floodplains (Conn et al. 2008; Villano and Mulder 2008).

Inventories of nonnative plant species in the assessment area have been conducted mainly along roads and trails and in other developed areas, so there is little information about establishment of nonnatives in native ecosystems in this area. It is assumed that there are few nonnative occurrences in intact ecosystems, but current infestations of invasives may be expected to spread over time unless treated.

Four weed inventories have been conducted in the assessment area. Duffy conducted a preliminary inventory in 2003, and DeVelice surveyed trails on the Kenai Peninsula in 2003. In 2006 Chumley and Klauser surveyed roadsides, campgrounds, beaches, trails, and agricultural lands. In 2008 navigable waters on the CNF were surveyed (Mohatt 2009). Areas along Quartz Creek that could be accessed were included in that survey. Chumley and Klauser found 41 species; 341 of the 432 acres surveyed had some level of nonnative plant presence. There is no accurate estimate of the amount of area covered by nonnative species in the State or in the assessment area. Most occurrences are very small (often much less than 0.1 acre). For example, one of the more frequently encountered weeds, red clover, covers a total area of less than 1 acre (based on data from the Forest spatial database).

In 2008 Carlson and others published a system for ranking the "invasiveness" of nonnative plants of Alaska. Species with a rank above 60 are considered the most invasive. They found most nonnatives restricted to anthropogenically disturbed areas, but some species showed alarming signs of spreading into natural areas. For instance, white sweetclover is a dominant species in previously sparsely vegetated riverbars in the interior, south-central, and southeast Alaska. A number of species known to cause economic and ecological damage in other states now occur in Alaska and over time may increase in abundance in Alaska (i.e., knapweeds, cheatgrass, purple loosestrife). Some species that do not cause problems in other states are strikingly invasive in Alaska (i.e., Siberian peashrub, Siberian wildrye, white sweetclover, European bird cherry, and bird vetch).

A total of 122 occurrences of 15 species are mapped in the GIS layer for the Quartz Creek Landscape Assessment area. Three of the species are not listed by the Alaska Natural Heritage Program (AKNHP) Weed Ranking Project (appendix C). Chumley and Klauser (2006) noted 20 additional nonnative plants in the assessment area. Of all the species known in the assessment area, 12 are not listed by the AKNHP Weed Ranking Project. Of those not ranked, two (*Achillea millefolium* and *Papaver nudicaule*) are not classified in PLANTS database as either invasive or native in Alaska (NRCS 2009). Three (*Turritis glabra, Hordeum jubatum,* and *Potentilla norvegica*) are listed as native to Alaska in PLANTS database. Chumley and Klauser also observed two revegetation grasses that are native species, but may not be native varieties (hairgrass and red fescue). Two of the weeds present in the assessment area (quack grass and hempnettle) are prohibited by the State of Alaska. The prohibited species were likely introduced during revegetation projects through use of contaminated hay bales (Duffy 2003).

Six species known from the assessment area have invasiveness rankings above 60 (considered most invasive): *Bromus tectorum* (cheatgrass), *Hordeum jubatum* (foxtail barley), *Leucanthemum vulgare* (ox-eye daisy), *Linaria vulgaris* (butter and eggs), *Lolium perenne* (perennial ryegrass), and *Melilotus alba* (white sweetclover). Several other species have rankings approaching 60 and may also be considered threats to native ecosystems (appendix C). Many weedy species take a long time to establish before becoming invasive; some species currently in the establishment phase may become more invasive in the future. Several other highly invasive species (appendix C) are known to occur in the vicinity of Quartz Creek and may occur in areas along the creek that have not been surveyed (Mahott 2009). The three species suspected to occur are all ranked greater than 60: *Hieracium arundinacea* (orange hawkweed), *Phalaris arundinacea* (reed canarygrass), and *Vicia cracca* (bird vetch).

The CNF weed program is coordinated out of the Forest Supervisor's office with support from district botanists and ecologists. The goal of the program is to treat 80 acres of weeds per year on the Forest and conduct follow up monitoring on 50 percent of treated acres. Priority species are those with Alaska Exotic Plant Information Clearinghouse (AKEPIC) rankings of greater than 65 (appendix C), but other species that appear to be invading undeveloped areas are also treated. Increased levels of treatment may be necessary in the future to keep pace with the spread of current infestations and establishment of new nonnative plant populations.

Fire and Fuels

The Quartz Creek Watershed currently experiences heavy human use as both a recreation area and as a travel corridor for people and commerce traveling to the east, south, and west ends of the Kenai Peninsula. The extreme west end of the project area is the unincorporated community of Sunrise, located on the shore of Kenai Lake. The analysis area also includes two Forest Service campgrounds (Quartz and Crescent) which receive moderate to heavy use throughout the summer season. Other infrastructure located in the analysis include an airfield at Sunrise, powerline corridors and fiber optic lines which run parallel to both highways, and a day use site at Tern Lake.

The Quartz Creek Watershed has experienced impacts from the latest cycle of spruce bark beetle infestation that started in the early to mid-1990s and proceeded through at least 2007. Estimates of total acreage affected by the latest infestation run as high as 1.4 million acres across the entire peninsula. Bark beetles have an impact on all spruce species and can result in tree mortality in all spruce species present; however, white spruce appears to be the most susceptible to major infestations. Initial impacts to fuels from beetle mortality result in a standing dead fuel model with intact trees loaded with dead needles. As the needles drop this aerial load decreases, but the surface load will increase as fine fuels (needle cast and branches less than ¼ inch) accumulate. An additional effect of the initial beetle infestation is the introduction of fungus and other decay agents by beetles as they feed/burrow through the infected tree's cambium layer. These "incidental introductions" weaken the bole of the now standing dead snag, essentially causing the dead trees to "fall apart" over the course of several seasons. As the dead standing timber collapses, the ground fuel load increases by several tons per acre. In addition to the increased fuel load created by the collapse of the spruce overstory, openings created increase the amount of sunlight reaching the ground surface. These openings are quickly colonized by disturbance-dependant species like *Calamagrastis* grass, fireweed, and other annuals which add to the fuel load. In some stands fuel loadings can amount to 12+ tons per acre and generate very intense fire behavior and rapid rates of spread.

Air Quality. Alaska periodically experiences air pollution from natural events including forest fires, volcanic eruptions, and high wind glacial dust storms. The municipalities of Anchorage, Fairbanks, and Juneau have experienced degraded air quality due to automobile exhaust and wood burning for home heating. Overall, Alaska residents enjoy a high degree of air quality.

Smoke, particularly from wildfires, has the potential to affect both local and regional air quality. Depending on its concentration, smoke from wildland fires can affect highway and aircraft safety, and affect visitor enjoyment. Fine particulate matter found in smoke can directly reduce local visibility and cause respiratory distress and disease in some individuals (NWCG 2001).

Temporary and short-term visibility impacts can be expected in the immediate area during actual wildfire and would be affected by wind speed and direction. Drainage inversions will affect nighttime dispersal of smoke, with possible smoke effects 5 to 10 miles down valley. Smoke from burning forest fuels can affect human health, particularly for the ground crews at the site.

Residents near the actual fire area may receive some respiratory discomfort; however, it is expected that most impacts will be in the form of nuisance smoke and/ or smell. Smoke from the wildfire and the associated emissions would reside in the local air-sheds a relatively short time depending on the weather and duration of fire. During the evening hours during a wildfire, some smoke would be expected to settle into the lower draws and drainages toward Anchorage, Cooper Landing, Seward, Moose Pass, and the Sterling Highway. Some signing may be needed along roads to warn the public of smoky conditions. Smoke trapped in low-lying areas would be expected to dissipate when the nighttime inversion lifted.

Aquatic Species and Habitats

Fisheries

Quartz Creek is a sub-watershed of the Kenai River system which supports the largest recreational sport fishery in the world (USDA Forest Service 2007b) and contributes to extensive commercial and subsistence fisheries (Benke and Cushing 2005). The Kenai River supports two distinct runs of Chinook, coho, and sockeye. The early run of Chinook enters the Kenai River in mid-May with the majority of the run through by late June (Benke and Cushing 2005). The majority of the early-run Chinook spawn in Killey and Funny Rivers and Quartz and Daves Creek from late July through August (Pappas and Marsh 2005). The late-run of Chinook enter the Kenai River in July and August and typically spawn in the main stem Kenai River (Pappas and Marsh 2005). After emergence the majority of juveniles will spend 1 year in freshwater (Flagg et al. 1986).

The early run of coho enters the Kenai in late July, and similar to the early-run of Chinook, primarily spawn in tributaries from September through early October (Benke and Cushing 2005). The late run coho, again similar to the late run Chinook, predominantly spawn in the main stem Kenai River (Benke and Cushing 2005). However the progeny of the late run coho can have extensive migrations from the main stem Kenai with many likely emigrating after emergence into the upper tributaries and lakes within the Quartz Creek Watershed where they will spend 1 to 3 years in freshwater, the majority of which residing in freshwater 2 years before migrating to the ocean (Pappas and Marsh 2005).

Similar to both Chinook and coho, sockeye also have an early and late run. However, in contrast to Chinook and coho, the early-run sockeye spawn predominantly in the Russian River with the late-run of sockeye spawning in the main stem below Skilak Lake and in various other tributaries such as Quartz Creek. Juvenile sockeye will typically rear in a nursery lake for 1 year with small percentages holding over for 2 years before undergoing smoltification (Flagg et al. 1986).

Pink salmon enter the Kenai River in late June and migrate to various tributaries to spawn in August. The ADF&G (Alaska Department of Fish & Game) database does not identify any spawning areas for pink salmon within the Quartz Creek Watershed; however, Forest Service fisheries personnel have documented spawning pink salmon in Daves Creek and numerous tributaries throughout the watershed (D'Amico 2009). After emergence, pink salmon fry immediately immigrate to the estuary of the Kenai River.

Chum salmon enter the Kenai River in mid June and migrate to areas of high upwelling to spawn in August. Chum have been documented spawning in the mouth of Quartz Creek from the Kenai Lake confluence up to the Daves Creek confluence (ADF&G GIS Data, 2007). Similar to pink salmon, chum migrate to the estuaries immediately after emergence in the spring.

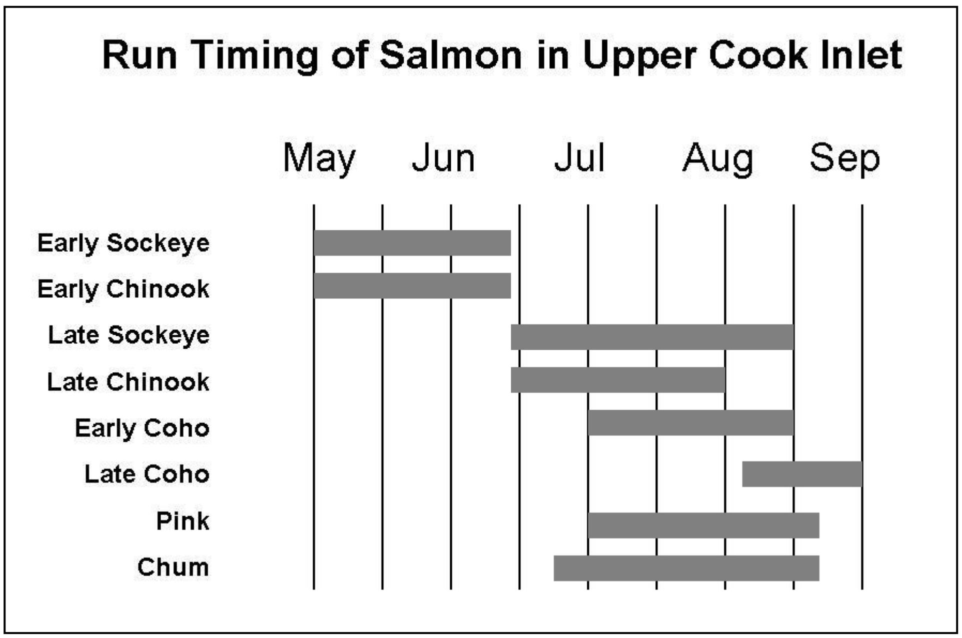

Figure 16. Salmon run timing for upper Cook Inlet (which includes the Kenai River)

Fishing

Fishing for salmon within the Quartz Creek Watershed is prohibited by ADF&G; however, salmon originating from the Quartz Creek Watershed are intercepted in the commercial, sport, and subsistence fisheries. In addition, Quartz Creek and tributaries support populations of wild rainbow trout and Dolly Varden char which supports significant sport fisheries.

Sport Fishing

The Kenai River supports the largest sport fishery in the world. ADF&G manages the Kenai River early- and late-run Chinook, coho, and early sockeye runs for sport fishing to provide sport and guided sport fishermen with reasonable opportunities to harvest. Various ADF&G regulations have been implemented to protect the salmon runs on the Kenai. These fisheries are often regulated on a day-to-day basis, so that emergency orders restricting the fishery can be applied if data suggest poor returns or otherwise lifted if returning fish numbers rebound or exceed predicted levels.

Sport fishing for rainbow trout and Dolly Varden within the Quartz Creek Watershed is very popular. Palmer and King (2005) stated "The Kenai River supports the largest road accessible sport fisheries for rainbow trout and Dolly Varden in Alaska. Participation in these fisheries has increased substantially in recent years with annual catches for each species sometimes exceeding 100,000 fish [on the Kenai River]."

Both rainbow trout and Dolly Varden char exhibit a variety of life histories, including anadromous, adfluvial, fluvial, and resident forms. The largest rainbow trout and Dolly Varden char within the Kenai River and Quartz Creek Watersheds are adfluvial and fluvial, meaning that they live in lakes and/or larger streams and rivers, respectively, the majority of time migrating into tributaries to spawn or feed on salmon eggs or juvenile salmon during peak spawning, emergence, or smolt migration periods.

Quartz Creek is also an extremely scenic place to fish, bounded by the glacial valleys of the Kenai Mountains. The Seward Highway provides easy angler access to the lower reaches of Quartz Creek. Special use permits are issued by the Forest Service to local guides for fishing on Quartz Creek. In 2005 there were 9 permitted fishing guides, 19 in 2006, and 20 in 2007. While permitted use increased from 334 allowed clients in 2005 to 860 clients in 2007, actual purported use remained relatively steady with 112, 155, and 102 clients fishing Quartz Creek in 2005, 2006, and 2007, respectively. Due to the relatively high angler use, some riparian areas and stream banks have been degraded due to heavy use and bank trampling along the more popular highway pull-outs.

In addition to the salmon and native trout and char fisheries, ADF&G stocks Jerome Lake with approximately 2,000 genetically altered triploid rainbow trout annually to enhance the trout sport fishery. In addition, arctic grayling were also stocked in Crescent Lake and several of the smaller alpine lakes within the watershed and are now naturally producing. ADF&G is currently conducting a radio telemetry study on the Crescent Lake grayling to evaluate migration and spawning distribution. Dwarf arctic char also known as "golden-fin" inhabit many of the alpine lakes in the headwaters.

Commercial and Subsistence Fishing

ADF&G manages the Upper Cook Inlet to minimize the harvest of northern and Central Cook Inlet Kenai River Chinook, coho, and early-run sockeye salmon. The Kenai River July or late run sockeye salmon run is primarily managed to provide harvest for commercial fishermen and personal use dip-net resident subsistence anglers. This run alone has historically made up about 50 percent of the total commercial salmon harvest in Upper Cook Inlet; about three-quarters of the statewide harvest of sockeye is taken from the Kenai River and its tributaries (Institute of Social and Economic Research 1996). Normal fishing periods for various salmon stocks within these districts can be restricted if escapement or other abundance indicators such as catch rate data or sonar estimates indicate the Department's sustained yield objectives for Chinook, coho, sockeye, chum, or pink salmon are not being met.

Fish Distribution and Existing Conditions

Quartz Creek. Quartz Creek contains the majority of available anadromous fish habitat within the Quartz Creek Watershed. All five species of Pacific salmon inhabit Quartz Creek; however, sockeye are dominant (Todd 1994). The majority of adult sockeye entering the watershed are late-run sockeye (Flagg et al. 1986) with spawning occurring in the main stem Quartz Creek from the Daves Creek confluence up to Slate Creek near Gilpatricks, and in Tern Lake Creek (ADF&G GIS Data 2007). In 1982–1984 an adult weir was placed in Quartz Creek to evaluate the hatchery broodstock potential of the drainage. A total of 70,500, 73,300, and 37,700 adult sockeye were passed above the weir in 1982, 1983, and 1984, respectively. The adult sockeye returns to Quartz Creek represented 12, 13, and 12 percent, respectively, of the total Kenai River sockeye escapement for these 3 years (King and Tarbox 1985). The majority of juvenile sockeye spawned in Quartz Creek emigrate downstream after emergence and rear in Kenai Lake for 2 years (Flagg et al. 1986; Todd 1994).

Chinook salmon were also sampled at the Quartz Creek weir from 1982 to 1984. Adult Chinook counts ranged from 337 to 497 during this period. Flagg et al. (1986) postulated that Quartz Creek was the second most important Chinook salmon spawning tributary of the Kenai River system. The Killey River was thought to be the most productive/important Chinook spawning tributary. Flagg et al. (1986) also found that river entry timing and peak spawning of adult Chinook returning to Quartz Creek did not fit well into either the early or late runs of Kenai River Chinook. The authors observed that Chinook salmon spawning within Quartz Creek peaked in early August, mid-way between the two early and late run peak spawning times of other populations observed on the Kenai River and tributaries.

The majority of adult coho entering Quartz Creek spawn from the Sterling Highway Bridge up to Slate Creek and in Daves Creek from the Quartz Creek confluence to approximately 1 mile upstream of Tern Lake (ADF&G GIS Data, 2007). ADF&G GIS data indicate that the majority of Chinook spawning within the Quartz Creek Watershed occurs in Daves Creek from the confluence of Quartz Creek up to the outlet of Tern Lake.

Chum salmon have been documented spawning in lower Quartz Creek below the Daves Creek confluence. Pink salmon spawn in the lower and middle reaches of Quartz Creek, Daves Creek, and the mouths of many of the tributaries.

Tern Lake and Daves Creek. The Tern Lake/Daves Creek system provides high quality spawning and rearing habitat for Chinook, coho, sockeye, and pink salmon; rainbow trout; Dolly Varden char; slimy sculpin; threespine stickleback; and round whitefish. ADF&G shows Daves Creek as the primary rearing habitat for Chinook in the watershed. Daves Creek is a 9.5-square-mile watershed which includes a small remnant glacier at the headwaters of "Upper Daves Creek," which flows north into Tern Lake. The Upper Daves Creek drainage produces abundant sediment that has produced an alluvial fan that has effectively dammed the valley floor and created the shallow 50-acre Tern Lake. The course of Daves Creek was also pushed against the northern valley wall by the Upper Daves Creek alluvial fan. Daves Creek proper originates at the Tern Lake outlet and flows approximately 6 miles downstream into Quartz Creek. The majority of Daves Creek is a low gradient, sinuous channel flowing through a wide, low gradient valley; although 2 miles downstream of Tern Lake the stream cuts through a shallow canyon as it drops down to the lower Quartz Creek Valley.

Unlike the sockeye which spawn in Quartz Creek, the majority of progeny from the sockeye that spawn in Tern Lake/Daves Creek rear in Tern Lake for up to 2 years after emergence; these fish were found to be genetically distinct from the other Kenai River stocks (Todd 1994). Flagg et al. (1986) estimated that the Tern Lake/Daves Creek system was producing between 17,000 and 29,000 adult sockeye, 75 percent of which would be harvested in the Cook Inlet commercial fishery. Flagg et al. (1986) also stated that Daves Creek provides better rearing habitat for both

Chinook and coho juveniles than the main stem of Quartz Creek because Daves Creek has lower gradient and slower water, with many small pools and abundant stream bank and instream cover. In addition, the springs and seeps within Tern Lake and percolating through the alluvial fan produce stable winter flows for Daves Creek and provide excellent overwintering habitat for salmonids.

Crescent Lake. Crescent Lake is a 22-square-mile lake in the southwest portion of the watershed. There is no road access to the lake; however, trail systems access the lake and there are two Forest Service cabins located on the lake. Crescent Lake supports an introduced, naturally producing population of Arctic grayling which provide a popular backcountry recreational fishery.

Crescent Creek. Chinook, coho, sockeye, and pink salmon have been documented by ADF&G anadromous fish data base and Forest Service personnel. Anadromous fish have access to approximately the lower 1.5 miles of stream (ADF&G GIS Data, 2007).

Dry Creek. Sockeye spawning has been documented by ADF&G in the lower 0.7 mile of Dry Creek. No other species information was available at the time of this report (ADF&G GIS Data, 2007).

Jerome Lake. ADF&G stocks Jerome Lake annually with approximately 2,000 genetically altered rainbow trout to enhance the trout fishery and to reduce fishing pressure of wild stocks. There is a "trickle" dam at the outlet of the lake to prevent stocked fish from migrating out of the lake. The dam also blocks fish from immigrating into the lake. The dam is approximately 40 years old and is in need of repair or replacement (Johansen 2009).

Jerome Lake Outlet. Coho spawning and rearing occur in the Jerome Lake outlet channel (ADF&G GIS Data, 2007). No other species information was available at the time of this report.

Johns Creek. Chinook rearing occurs in the lower 0.5 mile of Johns Creek (ADF&G GIS Data, 2007). No other species information was available at the time of this report.

Slate and Summit Creek. Coho spawning has been documented by ADF&G in Slate Creek to the confluence of Summit Creek (ADF&G GIS Data, 2007).

Devils and Henrys Creek. Fish species presence or distribution data was not available at the time of this report.

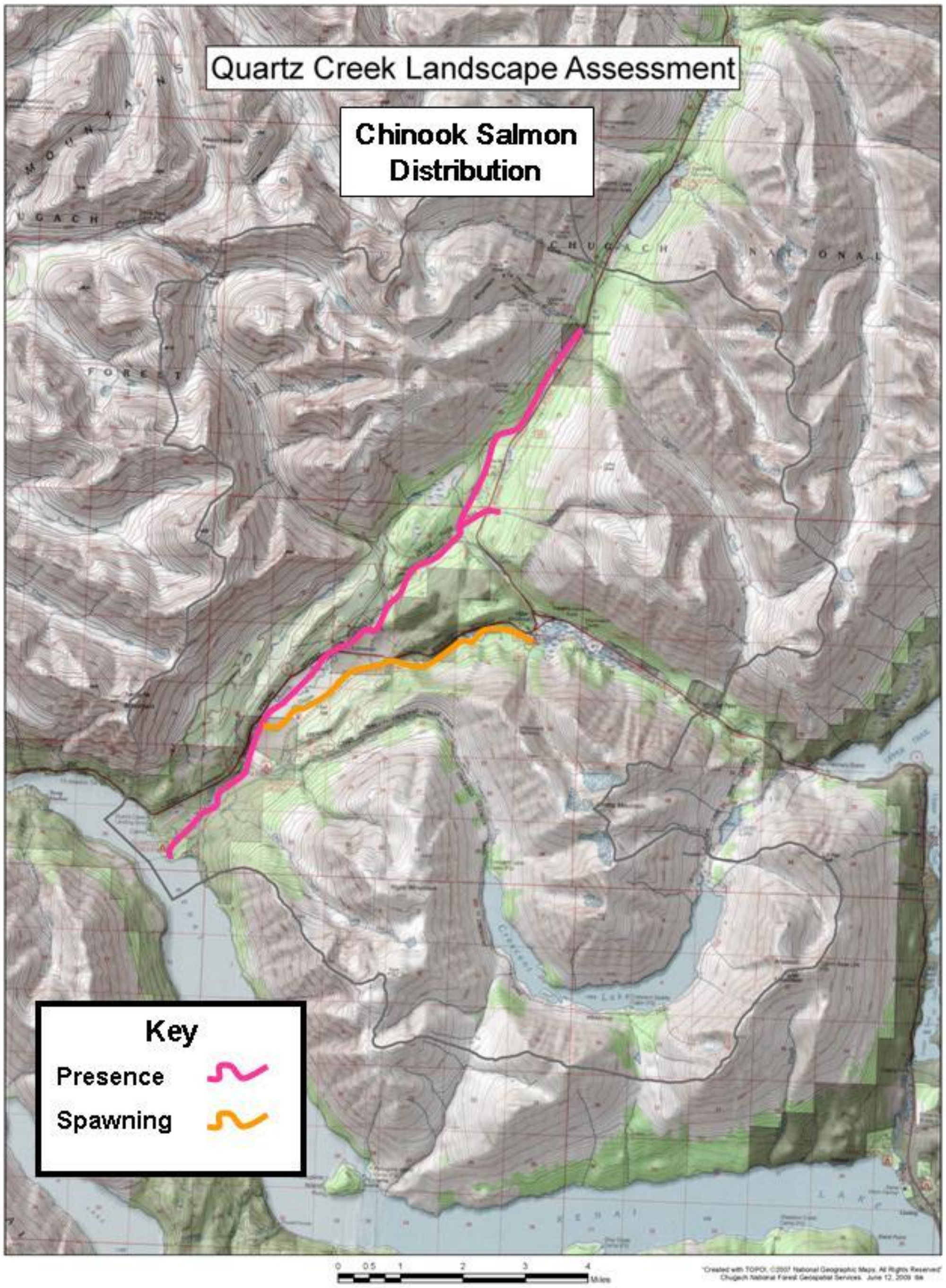

Figure 17. Chinook salmon distribution and documented spawning areas, Quartz Creek Watershed, Kenai Peninsula Alaska

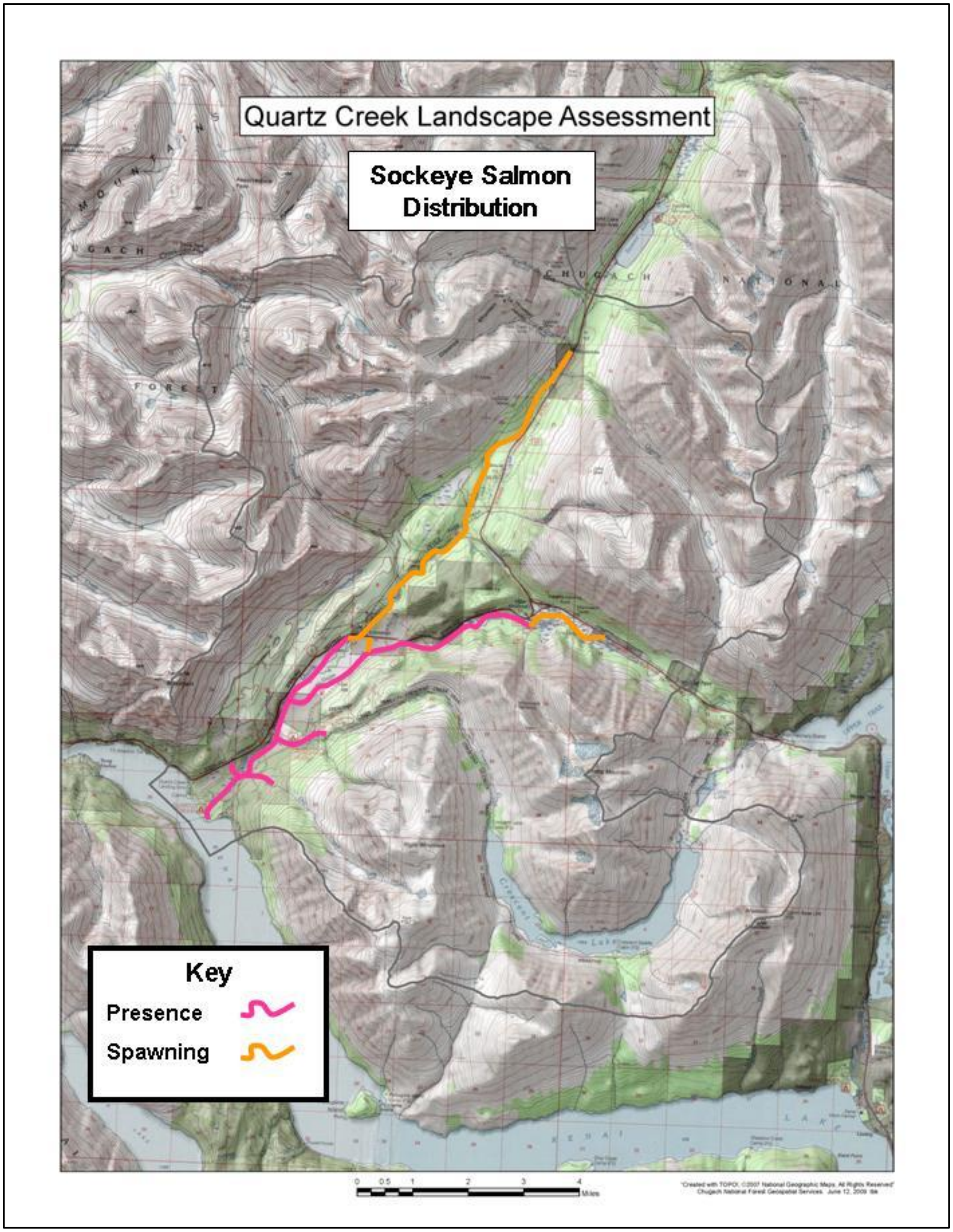

Figure 18. Sockeye salmon distribution and documented spawning areas, Quartz Creek Watershed, Kenai Peninsula Alaska

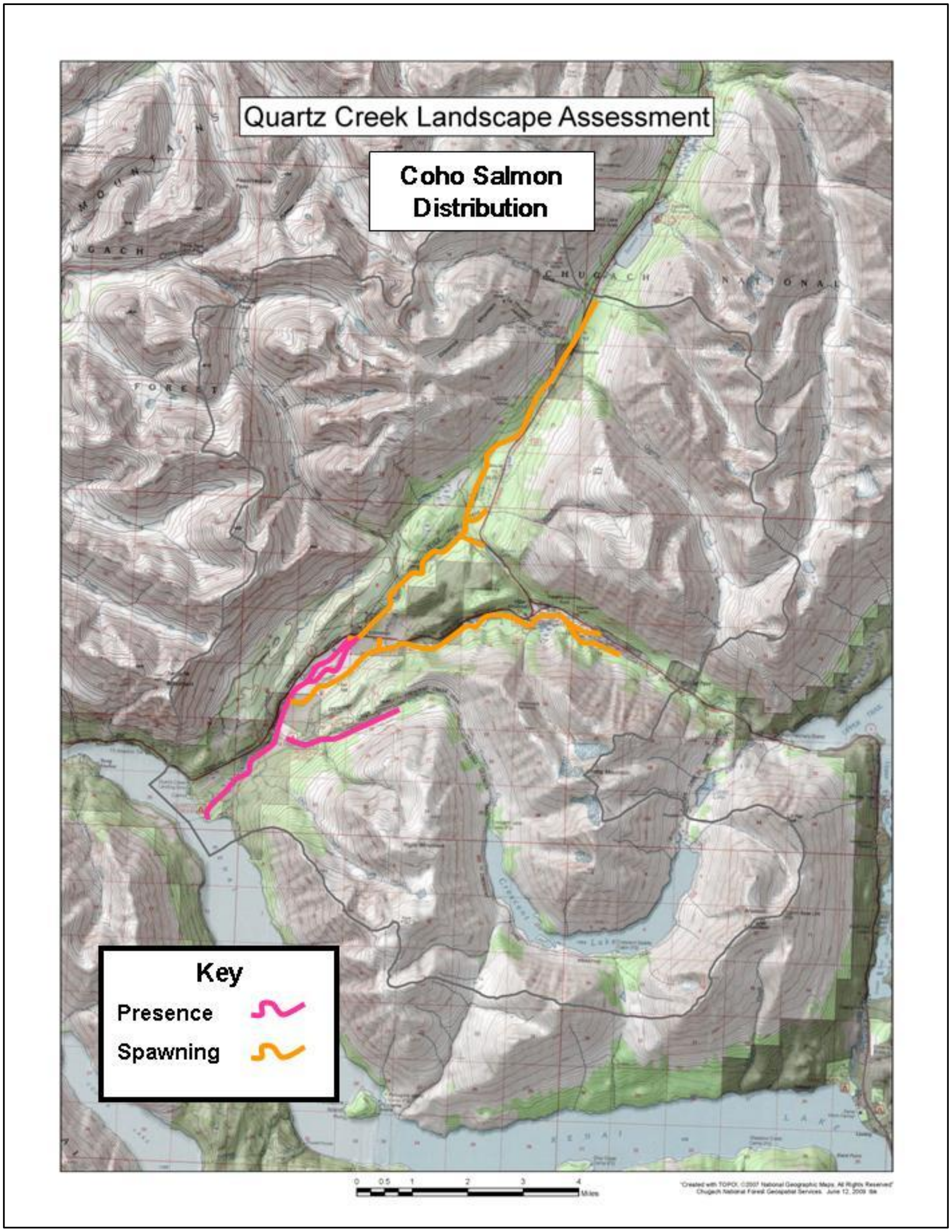

Figure 19. Coho salmon distribution and documented spawning areas, Quartz Creek Watershed, Kenai Peninsula Alaska

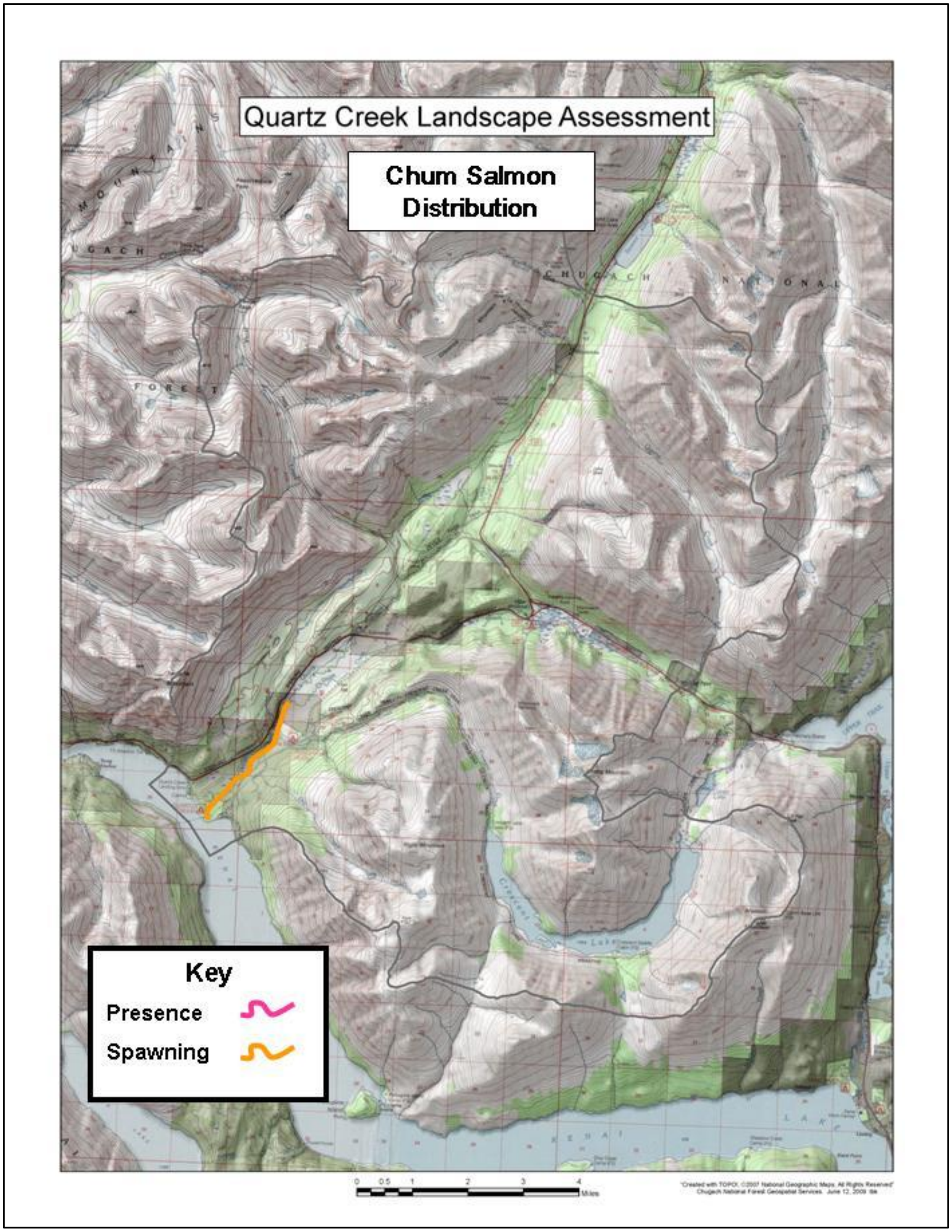

Figure 20. Chum salmon distribution and documented spawning areas, Quartz Creek Watershed, Kenai Peninsula Alaska

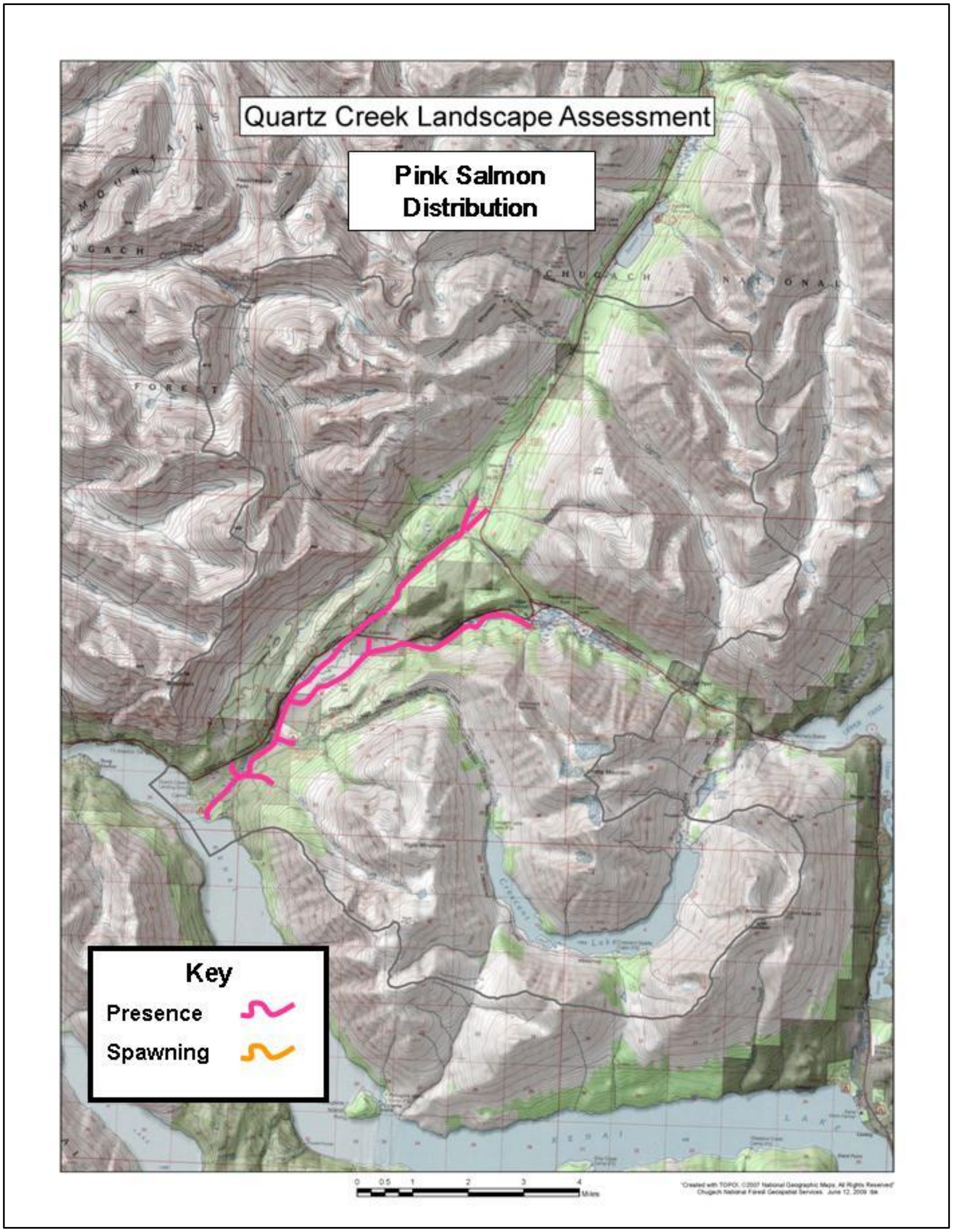

Figure 21. Pink salmon distribution and documented spawning areas, Quartz Creek Watershed, Kenai Peninsula Alaska

Aquatic Invasive and Nuisance Species

To date, Alaska has been somewhat of a refuge or "oasis" among the world-wide invasion of non-indigenous organisms which are causing environmental, human health, and economic harm (Fay 2002). This invasion of nonnative species is a result of increased trade and travel by humans. Many nonnative species move in as undetected hitchhikers and are unintentionally released (such as a release of green crabs in ballast water) while others are released as a result of ignorance or negligence (such as releasing aquarium fish into the wild). Some introductions are intended to benefit humans, such as the release of deer on Kodiak Island and Prince William Sound. However, many times these intentional introductions were not well thought out or researched and end up causing long-term environmental or economic harm, such as the release of mysis shrimp into Flathead Lake which caused the crash of the commercial and sport kokanee fisheries. Another example would be the introduction of reed canary grass to prevent erosion. The species spreads rapidly and out-competes native vegetation; it now dominates many of the riparian areas in both the continental United States and within many Alaska streams and lakes. In general, introductions of exotic species in any ecosystem usually results in a very negative impact on the native flora and fauna.

Aquatic invasive species pose a significant threat to the ecosystems, fisheries, and economies of south-central Alaska. Non-indigenous species such as northern pike (*Esox lucius*) and yellow perch (*Perca flavesens*) have been illegally introduced into the Kenai River Watershed by misguided anglers. Atlantic salmon (*Salmo salar*) have also been found in streams near Ketchikan, Cordova, and Yackutat, and as far north as the Bering Sea.

Development

The road density within the Quartz Creek Watershed is 0.3 miles per square mile. Impacts to watershed hydrology and stream channel morphology are typically not observed in watersheds with road densities less than 2 miles per square mile.

There is one campground located at the mouth of Quartz Creek, the Quartz Creek Campground, and a large day use/picnic facility located at Tern Lake. The Crescent Creek Campground and the Crescent Creek Road Bridge have generated negative dynamic channel changes in the lower half-mile of Quartz Creek. The lower reaches are low gradient (<1 percent) and have a naturally dynamic C4 Rosgen channel with very high sinuosity. As previously discussed in the Hydrology section of this analysis, the Crescent Creek Road Bridge and road prism have caused the stream to increase meandering above the bridge and is causing erosion to the road bed delivering fine sediment into the reach below where chum salmon spawn.

In 2000 the Forest Service, in cooperation with the Youth Restoration Corps, worked to restore riparian vegetation and bank stability near the Quartz Creek Campground where angler trampling damaged the banks and caused increased erosion rates. Monitoring of the site has continued to present.

A gravel pit was constructed on the west side of Quartz Creek immediately upstream of the Sterling Highway in the 1950s during construction of the highway. This gravel pit has now become a pond in the floodplain of Quartz Creek. Fish access into the pond is not known at this time.

Upstream of the Sterling Highway and the mouth of a slightly incised canyon section on Quartz Creek, the channel exhibits excess gravel deposition, with wide unvegetated gravel bars, shifting channels, and multiple channels in places. This reach represents the transition area between the steeper Upper Quartz Creek (average gradient 2.2 percent) and the flatter Lower Quartz Creek (average gradient 0.4 percent), where sediment is deposited because of the loss of energy to transport sediment. This area also contains a powerline crossing and is adjacent to the electrical power station. There is a designated low-water ford which accesses the power station which appears to be artificially constricting flow and maybe exacerbating the observed channel instability in this reach. In addition, dispersed recreational campsites within the area are also impacting riparian areas.

The original course of the Sterling Highway included a bridge crossing the Tern Lake outlet. The highway was reconstructed in the 1940s on the north side of Daves Creek. Rather than build numerous bridges over Daves Creek, the stream course was re-routed into a constructed channel along the south side of the highway. The result was a 1-mile reach characterized by a ditch-like channel with little sinuosity and poor connectivity with its floodplain, unstable banks, and extremely poor fish habitat. In addition, highway traction sand and gravel was entering the stream altering stream substrate composition, negatively impacting fish spawning gravel. In addition, the right bank along the highway was periodically “brushed” greatly reducing riparian function.

In the 1960s a Forest Service campground was constructed on the west side of Tern Lake, and the old Sterling Highway Bridge was removed and replaced with a 42-foot-long, 8-foot-wide culvert (Bair et al. 2006). The culvert at the outlet maintained the elevation of the lake outlet or may have even caused the water level in the lake to increase. Installation of the culvert also reduced the conveyance capacity of water at the outlet, causing greater increases in the lake elevation during floods than occurred previously with the bridge in place (Blanchet 2003). Further, modeled flows simulated through the Tern Lake outlet culvert into Daves Creek were velocity barriers to juvenile salmon, trout, and char 3 inches and less in length (Bair et al. 2006).

In the 1980s, the Forest Service placed three full-span log weirs in the 235-foot reach immediately downstream of the culvert to help fish passage into Tern Lake and provide pool habitat. However, the weirs were each 1 to 2 feet high and may have also been a barrier to juvenile and resident fish attempting to emigrate into Tern Lake.

In 2009 a project was initiated by the Forest Service, Kenai Sport Fishing Association, and partners to restore fish passage at the culvert in to Tern Lake and to rehabilitate fish habitat in the 2,000 feet of stream channel which was placed into the Sterling Highway road ditch in the 1940s. The 8-foot-diameter culvert was removed and replaced with a bridge spanning 23 feet. In addition, approximately 1,600 feet of new stream channel were constructed away from the highway, and the log weirs were significantly modified to reduce fish jump height and increase fish passage. The new stream channel was created with a series of pool, riffle, and glide habitat to increase spawning, rearing, and hiding cover for fish with the ultimate goal of increasing fish production both within Daves Creek and the Quartz Creek Watershed.

Terrestrial Species and Habitats

The diverse mosaic of habitat types within the Quartz Creek Watershed supports an array of large game and other non-game animals. Table 8 lists the existing and potential habitat for important species within the watershed, including threatened, endangered, or sensitive species (TES), management indicator species (MIS), or species of special interest (SSI). “Existing habitat” notes the species has been documented to occur. “Potential habitat” provides suitable habitat characteristics, although it is currently not known to be occupied by the species.

Table 8. Existing or potential habitat for TES, MIS, and SSI in the watershed

Species	MIS	TES	SSI	Existing Habitat	Potential Habitat
Humpback Whale		X		NO	NO
Beluga Whale[2]		X		NO	NO
Steller Sea Lion[2]		X		NO	NO
Steller's Eider[2]		X		NO	NO
Kittlitz's Murrelet[2]		X		NO	NO
Dusky Canada Goose[2]	X	X		NO	NO
Aleutian Tern[2]		X		NO	NO
Black Oystercatcher[2]		X		NO	NO
Brown Bear	X			YES	YES
Moose	X			YES	YES
Mountain Goat[1]	X			YES	YES
Gray Wolf			X	YES	YES
Canada Lynx			X	YES	YES
Marbled Murrelet[1]			X	UNKNOWN	YES
Montague Island Hoary Marmot[1]			X	NO	NO
River Otter			X	YES	YES
Sitka Black-tailed Deer			X	YES	YES
Townsend's Warbler			X	YES	YES
Wolverine			X	YES	YES
Bald Eagle			X	YES	YES
Northern Goshawk			X	YES	YES (foraging)

Sensitive Species

There is no existing or potential habitat for sensitive species in the watershed.

Management Indicator Species

Moose

Moose are primarily associated with early to mid-succession habitat and riparian areas (USDA Forest Service 2002b) and are dependent on early-seral vegetation types including young hardwoods (willow, birch, aspen, and to a smaller extent, cottonwoods). The availability of winter range is the major limiting factor for moose population size. On the Kenai Peninsula, other limiting factors include predation, hunting, and mortality from vehicular collisions (Lottsfeldt-Frost 2000). Renecker and Schwartz (1998) found that the distance between feeding and hiding/thermal cover also can be a limiting factor, especially in areas of large-scale disturbance.

CNF GIS data indicate that moose winter range exists on 9,185 acres within the watershed, primarily surrounding Quartz and Daves Creek and south of Summit Lake (see Figure22). The Sterling Highway runs through the center of the large area of winter range.

Collaring data collected in partnership with ADF&G on moose habitat and movements show four collared moose in the watershed in the winter. One moose primarily used the area in Quartz, Devils, and Daves Creeks during the winter, while the other three appeared to only pass through and primarily used the Juneau drainage. The Quartz, Daves, and Devils Creek drainages may function as travel corridors for moose. The Seward and Sterling Highways bisect this travel corridor; and Alaska state trooper records indicate 32 moose have been killed along the 2 highways from 2000–2009, particularly at mile 40 and 43 of the Seward Highway (both areas contain wetlands or small ponds) and between mile 40–42 of the Sterling Highway. Mile 40 is near the substation, where Daves Creek crosses the highway, and moose forage along Daves Creek. Mile 40–42 is winter range where Daves Creek runs close to the highway. Animals may be crossing to access Quartz Creek, traveling up to Devils Creek (see Figure 23). These areas may indicate both foraging areas and travel corridors or areas of habitat connectivity.

The ADG&F considers the overall habitat on the Seward Ranger District to be of low quality and capable of supporting only two to five moose per square mile.

Figure 22. Moose habitat within the Quartz Creek Landscape Assessment Area

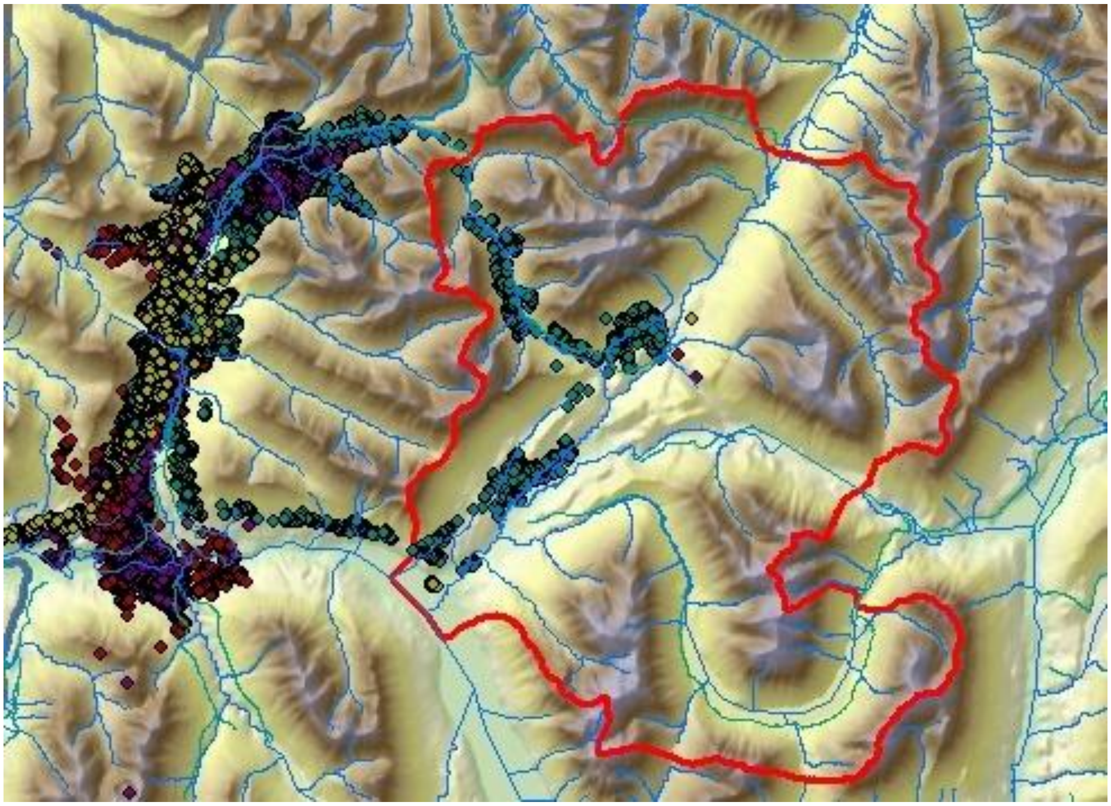

Figure 23. Collared moose data points in and around the Quartz Creek Landscape Assessment Area

Early-seral hardwoods currently exists on less than 1 percent of the watershed (402 acres early-aspen and birch and 261 acres of willow), providing limited browse for moose. Numerous habitat or fuel reduction projects have naturally or purposefully regenerated hardwoods for moose (Quartz 35, Quartz South, and Quartz East; and various timber sale/fuel reduction projects in the 1980s). Even with these projects, early-seral hardwood areas are limited to about 1 percent of the watershed.

Mountain Goat

Mountain goats use cliffs, alpine, subalpine, and old-growth habitats and are generally found near steep cliffs with slopes greater than 50 degrees. In south-central Alaska, winter habitat may be a limiting factor for mountain goat populations. They are also sensitive to low-level aircraft flights over summer alpine kidding habitats and wintering areas (USDA Forest Service 2002b).

Based on CNF GIS data, mountain goat winter range primarily occurs on south-facing alpine slopes spread throughout the watershed on approximately 7,610 acres (see figure 24).

Mountain goat populations appear to be stable in most of the watershed (McDonough 2009). Goats occur in three units managed by ADG&F, units 332, 334, and 338. The goat numbers in 334 have been stable at about 100 goats for the past 20 years. For area 338, the goat numbers have been relatively stable for 20 years at 30 to 40 goats. For 332, the goat numbers have declined slightly in the past 10 years to about 50 goats.

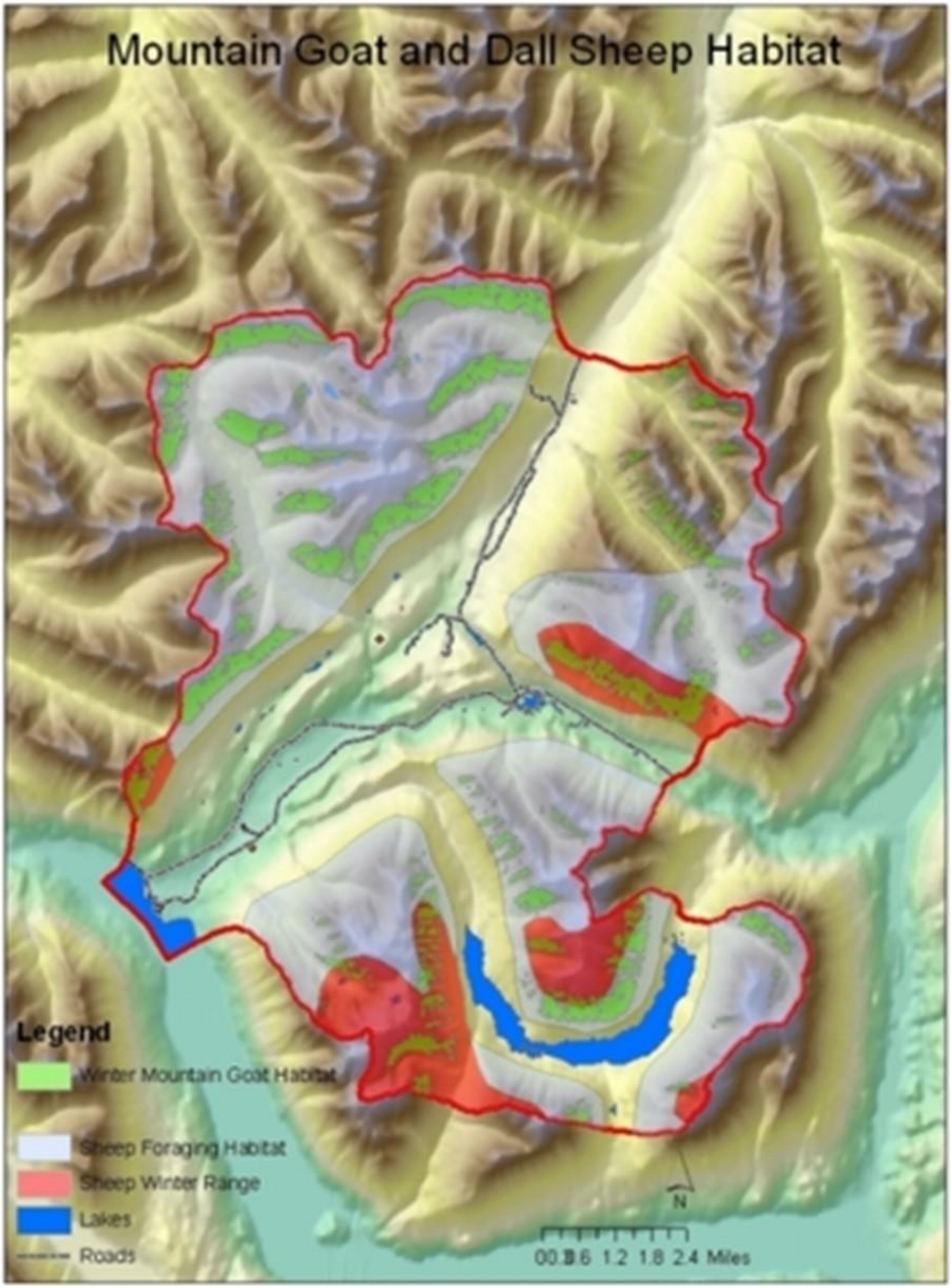

Figure 24. Mountain goat and Dall sheep habitat within the Quartz Creek Landscape Assessment Area

Brown Bear

Brown bears have large home range requirements and are generally intolerant of human activities and development. Suring et al. (1998) estimated the Kenai Peninsula population at 280 bears, or about 12 bears per 386 square miles. This is an estimate and ongoing work collecting hair samples and analyzing DNA in cooperation with ADF&G and U.S. Fish & Wildlife Service will assist in updating population estimates.

On the Kenai Peninsula, the primary limiting factor is spring and summer feeding habitat. Spring and summer habitat includes south-facing hillsides and avalanche chutes, big game winter ranges, and salmon streams that provide the high quality foods that bears need to develop fat reserves before denning and to replenish fat stores depleted after denning. Carrion, berries, and fish sources in the watershed provide a diversity of food for bears.

Brown bear habitat important during the winter includes brown bear core areas identified in the Forest Plan, potential denning habitat, and post-den emergence habitat (spring habitat), particularly for females with cubs. Brown bear core exists on 25,309 acres surrounding Crescent Lake.

Graves et al. (2007) reviewed GPS collaring data from brown bears collared between 1995 and 2002. The area reviewed covered 42,198 acres within the watershed, which is about three-quarters of the area. Of this, they found that 4,342 acres were not considered bear habitat, 10,447 acres were primary habitat, and 27,408 acres were potentially bear travel corridors.

The best potential denning habitat was identified from a denning habitat model developed by Goldstein et al. (2010). This model predicts the probability of denning across the landscape. Brown bears may den on steep slopes throughout the watershed. Habitat predicted by the model to have an 80 to 100 percent probability of being used was overlaid on habitat determined by Graves et al. (2007) as being primary habitat or corridors. Areas that met both criteria occur on 454 acres of steep slopes near Crescent Lake, Quartz Creek, Daves Creek, and Tern Lake.

Suring et al. (2005, page 13-14) found when female brown bears with cubs leave dens, they are more associated with upland habitats in close proximity to cover. Suring's brown bear model determines the potential for habitat use in terms of probability. He estimates that the areas with a probability of 80 to 100 percent have the highest potential for use.

The effects of recreation on brown bears in the watershed are currently unknown. Recreation trails run through primary bear habitat and bear corridors (Graves et al. 2007) in the core area (Carter Lake Trail) and at the beginning of the Devils Pass Trail near the Seward Highway, as well as along the dirt road called the Old Sterling Highway. Campgrounds and recreation activities such as hiking, fishing, or mining occur near salmon streams where bears are known to forage (Quartz Creek, Crescent Creek, and Devils Creek). The amount of recreation use and the numbers or trends in bear/human interactions are unknown. Suring's brown bear model indicates that 222 acres of habitat with the highest potential for use by female bears with cubs could be affected by winter recreation. Flight seeing and flight training activities occur in the watershed and in the core area. This activity is generally not managed by Forest Service permits, so the amount and effects on brown bears are unknown.

On the Kenai Peninsula, the Sterling Highway has been posted as a potential barrier to brown bear movement (Graves et al. 2007). Because dispersal of young bears occurs very gradually, and because human activities directly increase mortality risk of such dispersers, particularly for females (McLellan and Hovey 2001), researchers have predicted that areas with seasonal habitat importance and low levels of human activities are required to maintain sufficient dispersal success and prevent habitat fragmentation (Servheen and Sandstrom 1993). Such areas have been termed linkage zones. Because linkage zones should have movement characteristics that are equivalent to primary habitat, Graves et al. (2007) identified primary habitat patches intersecting with the Sterling Highway as linkage zones, including an area east of Kenai Lake within the Quartz Creek Watershed (this area is identified as primary habitat along the Sterling Highway). Brown bear habitat connectivity is likely affected by roads in this watershed. Approximately 18 miles of road intersect potential travel corridors based on data from Graves et al. (2007). Of those 18 miles, 8 miles are along the Seward and Sterling Highways.

Roads and trails, other existing development, and increasing levels of recreational activities in the watershed may reduce the quality of available habitat and increase the number of negative bear-human encounters. On the Kenai Peninsula, habitat modification and human activities have resulted in an increase in the number of brown bears killed in defense of life or property (DLP) (Suring and Del Frate 2002). During the summer, bears concentrate along low-elevation valley bottoms and coastal salmon streams in areas that are heavily used by people. Salmon congregate in Daves Creek, Quartz Creek, Devils Creek and other streams (see the Fisheries section). Encounters may occur at salmon streams or along trails resulting in injury to humans and injury or death to brown bears. Brown bears use areas along Quartz Creek, Daves Creek, Devils Creek and other tributaries during salmon runs. At least two brown bears were shot along the Crescent Lake trail in recent years (O'Leary 2009). DLPs that occurred over the last 13 years are shown in table 9. When considering DLPs in 5-year increments, from 1996–2000 there was one DLP, from 2001–2005, there were three DLPs, and from 2006–2009 (only 4 years) there were four DLPs. It appears that DLPs are slowly increasing over time.

Table 9. Brown bear DLP occurrences from 1996–2009

Year	# DLPs
1996	1
1997	0
1998	0
1999	0
2000	0
2001	1
2002	0
2003	0
2004	1
2005	1
2006	2
2007	1
2008	1
2009	0

Species of Special Interest

Bald Eagle

Bald eagles in south-central Alaska generally nest in old cottonwood trees near water and use the same nest each year (Daum 1994). The proximity of large nest trees to food sources is the primary limiting factor for the bald eagle population. Approximately 80 percent of all bald eagle nests on the Seward Ranger District are in mature cottonwood trees with an average diameter of 31 inches and within one-quarter mile of an anadromous fish-bearing stream.

There are 17 known bald eagle nests in the watershed, primarily concentrated along Crescent Lake, Quartz Creek, Daves Creek, Tern Lake, and Summit Lake (figure 25). Information on historic populations of bald eagles is not available. Habitat impacts, if they exist in the watershed, are likely related to natural disturbances such as flooding and human disturbance from recreation and aircraft.

Figure 25. Known bald eagle and northern goshawk nest areas

Wolverine

The wolverine is a scavenger and opportunistic forager with a low biotic potential and large home range requirement. Similar to the brown bear, it is sensitive to human activities and development. Recreational uses and hunting may limit populations.

Little is known about wolverine populations and their use of the watershed. Wolverines travel over a wide range of habitats in search of food such as big game carrion (moose and goats). Aerial track surveys were conducted by Golden in 2004; track groups were noted in Quartz and Crescent Creeks. Surveys and radio collaring efforts in 2007 indicated one wolverine using the area surrounding Crescent Lake before it was trapped and killed. Survey efforts in 2009 did not cover the watershed.

Northern Goshawk

The northern goshawk is an uncommon forest raptor that feeds on small and medium-sized mammals and birds (Iverson et al. 1996). They are year-round residents of the CNF (USDA Forest Service 1984). The amount and juxtaposition of feeding and nesting habitat appears to limit population viability in southeast Alaska (Iverson et al. 1996). The nesting-breeding season is from March to July. The majority of goshawk nests on the Seward Ranger District are in old growth hemlock-spruce stands characterized by a closed canopy, large average diameter, gap regeneration, and an open understory (Seward Ranger District goshawk nest files).

There are two known northern goshawk nests located in the watershed near Quartz Creek and Devils Creek, and more may occur (see figure 26). Few surveys have been conducted to determine if goshawks are present and breeding in the remainder of the watershed. They have been reported along the west end of Crescent Lake Trail. Stand classifications for the 27 known goshawk nests were reviewed using the 2007 Kenai Peninsula Borough vegetation map (see appendix B). Approximately 80 percent of nests were in large hemlock or spruce stands with closed canopies. About 15 percent of nests were in pole-sized birch stands and 4 percent were in large aspen/birch stands. Using the same stand classification, stands were identified that may offer potential habitat (see figure 26). The majority of potential habitat surrounds the Seward and Sterling Highways. Opportunities exist to treat some of these areas to reduce fuels, enhance current potential habitat, and promote nesting habitat in large areas surrounding known territories (see opportunities and recommendations).

River Otter

River otters are associated with coastal and fresh water environments and the immediately adjacent (within 100 to 500 feet) upland habitats (Toweill and Tabor 1982; USDA Forest Service 2002b). Beach characteristics affect the availability of food and cover, and adjacent upland vegetation provides cover (USDA Forest Service 2002b). Otters travel several miles overland between bodies of water and develop well-defined trails that are used year after year (USDA Forest Service 2002b). River otters breed in late winter or early spring. Young are born from November to May with a peak in March and April (Toweill and Tabor 1982). The family unit usually travels over an area of only a few square miles (USDA Forest Service 2002b).

Figure 26. Potential goshawk nest habitat within the Quartz Creek Landscape Assessment Area

Data on river otter populations in the watershed are lacking, but local residents report seeing them in Tern Lake and Quartz Creek. Potential habitat exists in Carter, Crescent, and Summit Lakes and in Quartz Creek.

Lynx

Lynx use a variety of habitats, including spruce and hardwood forests, in early successional communities. They require a mosaic of conditions, including early successional forests for hunting and mature forests for denning (Koehler and Brittell 1990). Lynx habitat in Alaska occurs where fires or other factors create and maintain a mixture of vegetation types with an abundance of early successional growth (Berrie 1973; Berrie et al. 1994). In Alaska, lynx tend to use elevations ranging from 1,000 to 3,500 feet and seldom use unforested alpine slopes (Berrie 1973). Mating occurs in March and early April, and kittens are born 63 days later under a natural shelter such as a wind-fallen spruce or rock ledge (Berrie et al. 1994). Cyclic changes in snowshoe hare and other small mammal populations (Poole 1994) influence the production and survival of lynx kittens dramatically. The populations of lynx on the CNF are thought to be stable and within the range of historic viability (USDA Forest Service 2002b). Lynx probably occur throughout forested sections of the watershed, but no data are available.

Early-seral hardwoods and conifers are currently limited in the watershed, so promoting these structural stages will be beneficial to lynx.

Marbled Murrelet

Marbled murrelets are medium sized seabirds that inhabit near-shore coastal waters and inland freshwater lakes, and nest in inland areas of old-growth conifer forest or on the ground (Carter and Sealy 1986; Marshall 1988). Except for the fall period when they are molting, flightless, and stay on the ocean, murrelets are known to fly to tree stands.

Marbled murrelet surveys have not been conducted in the watershed. Murrelets may use mature or old growth conifers for nesting; many of the large spruce have been affected by the spruce bark beetle. The majority of the watershed is within 30 miles of the coast, a distance which murrelets are known to travel inland for nesting. Areas of mature conifer forest are displayed in figure 27. These areas may contain some potential nest habitat.

Townsend’s Warbler

Townsend’s warblers are found throughout forested locations on the Seward Ranger District. They are associated with older, mature spruce and hemlock forests and are not found as often in young coniferous or hardwood forests.

The Seward Ranger District has one point count route within the watershed along the Devils Pass Trail. Surveys on this route have been conducted sporadically since 1994. Townsend’s warblers have been identified during all surveys (2002, 2003, and 2004) and were fairly common. Results from surveys taken at these and other locations on the district indicate that Townsend’s warblers are found in higher numbers in older spruce and hemlock forests, and that they have declined in numbers between 1994 and 2000 (Prosser 2002).

Townsend’s warbler habitat likely occurs throughout mature hemlock and spruce-hemlock forested sections of this watershed. Mature conifer forests and potential habitat for Townsend’s warblers are displayed in figure 27.

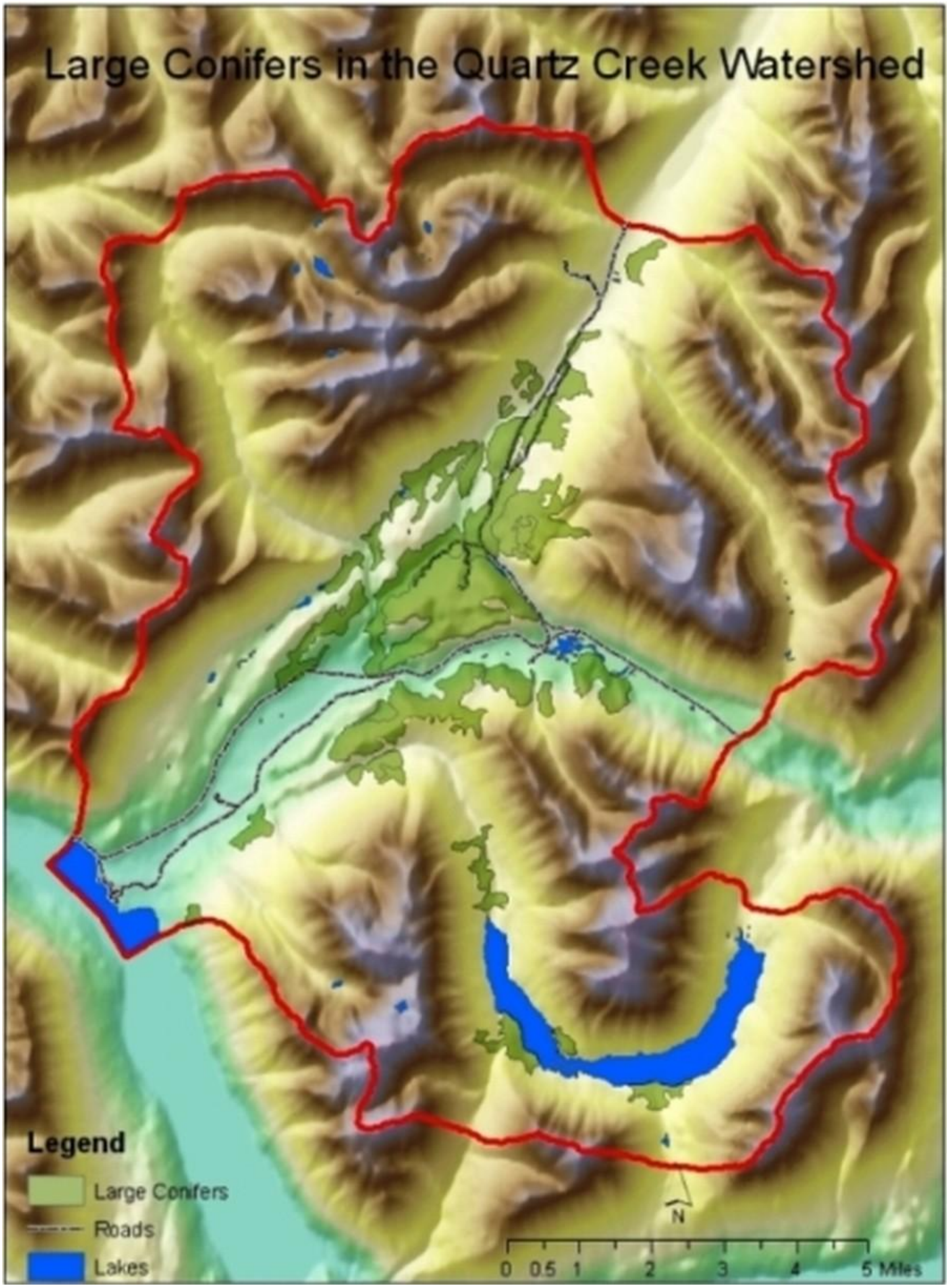

Figure 27. Large conifers potentially providing habitat for species needing mature or old growth forest

Gray Wolf

Wolves are habitat generalists. During winter, wolves are found at lower elevations in forested or woodland areas (Stephenson 1994). Wolves are highly social animals and usually live in packs that include parents and pups of the year. Pack size usually ranges from 2 to 12 animals. In Alaska, the territory of a pack often includes from 300 to 1,000 square miles of habitat, with the average being about 600 square miles (Stephenson 1994). Wolves normally breed in February and March, and pups are born in May or early June (Stephenson 1994). One pack of wolves was known in the past to use the watershed (Spraker 2001). Tracks and sightings have been noted by locals in the watershed near Tern Lake and Crescent Lake, and on two instances, wolves were hit by cars near the Devils Pass trailhead at mile 44.

Other Species of Interest

Dall Sheep

Dall sheep winter range occurs on 7,529 acres, north of Tern Lake, on Languille Mountain, and north of Crescent Lake (see figure 24). Sheep numbers in the watershed have generally been stable. There are no sheep that reside in area 334. For area 338, the sheep have been relatively stable at about 100 to 200 sheep for the past 20 years. For 332, sheep appear to have declined to about 100 (McDonough 2009).

Barren Ground Caribou

Caribou foraging habitat exists on 7,765 acres in the northwest corner of the watershed surrounding the Devils Pass and Summit Trails (see figure 28).

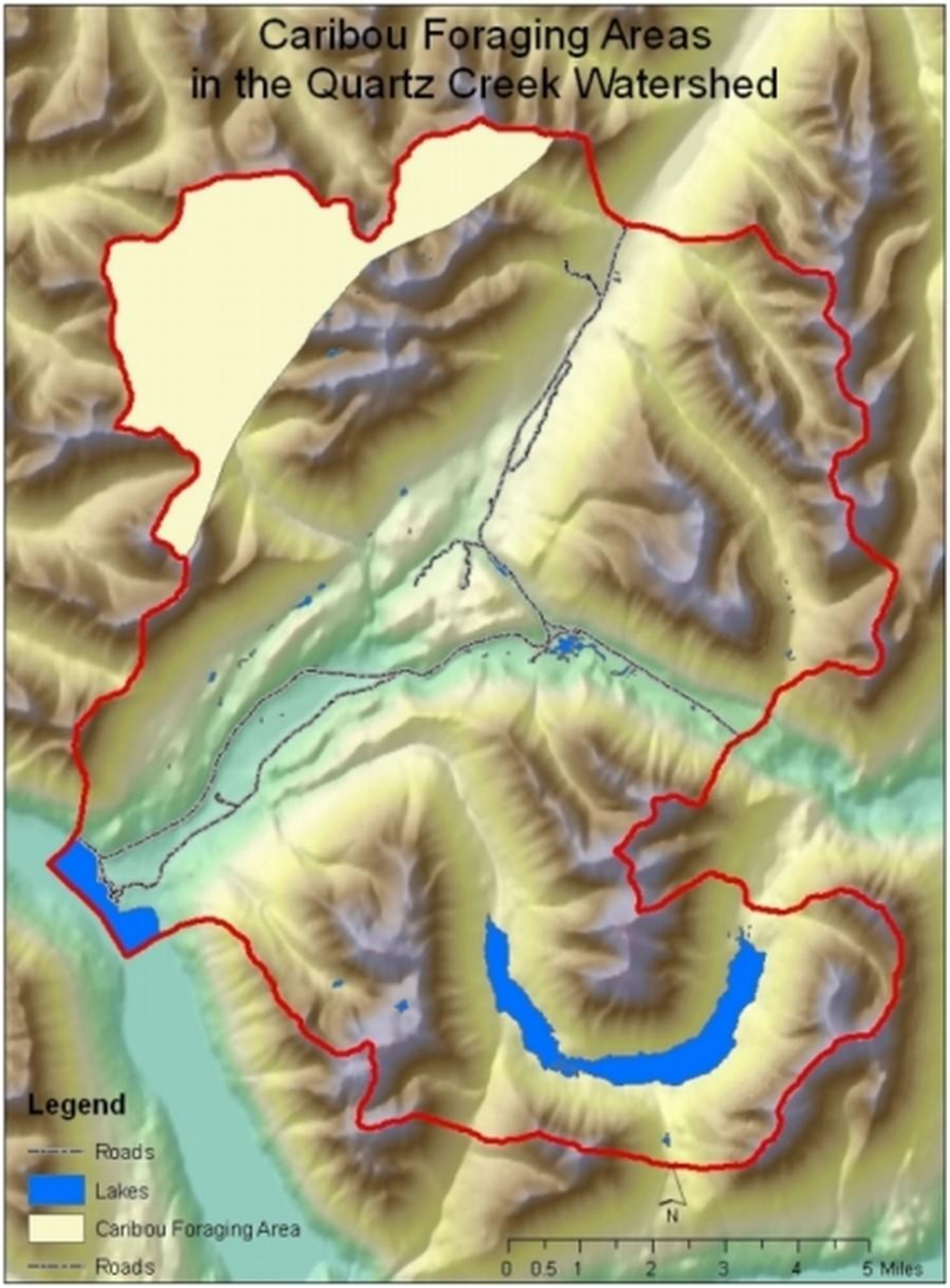

Figure 28. Caribou habitat within the Quartz Creek Landscape Assessment Area

Migratory Birds

The Devils Pass Neotropical Bird surveys conducted in 2002–2004 noted numerous migratory birds (see table 10). The point-count route is typical of much of the vegetation found in the watershed.

Table 10. Migratory birds of the Devils Pass Trail Neotropical Bird Route

2002	2003	2004
Black Cap Chickadee	Black Cap Chickadee	Gray Jay
Boreal Chickadee	Golden-crown Kinglet	Boreal Chickadee
Ruby-crowned Kinglet	Ruby-crowned Kinglet	Golden-crown Kinglet
Swainson's Thrush	Swainson's Thrush	Ruby-crowned Kinglet
Hermit Thrush	Hermit Thrush	Swainson's Thrush
American Robin	Varied Thrush	Hermit Thrush
Varied Thrush	Orange Crowned Warbler	Varied Thrush
Orange Crowned Warbler	Yellow Warbler	Orange Crowned Warbler
Yellow Warbler	Townsend Warbler	Yellow Warbler
Myrtle Warbler	Yellow Rumped Warbler	Townsend Warbler
Townsend Warbler	Wilsons Warbler	Yellow Rumped Warbler
Northern Waterthrush	Golden-crown Sparrow	Wilsons Warbler
Wilsons Warbler	Slate-colored Junco	Slate-colored Junco
Song Sparrow	Pine Grosbeak	Pine Grosbeak
White-crowned Sparrow	White-winged Crossbill	
	Common Redpoll	
	Pine Siskin	

Heritage

Approximately 6 percent (4,516 acres) of the landscape assessment area has been surveyed for cultural resources. Forty-nine prehistoric and historic cultural sites have been identified and inventoried in the course of these surveys. Summary data about these sites is provided in table 11; summary information concerning National Register eligibility for these sites is provided in table 12. These sites have been reported to the Alaska State Historic Preservation Officer (SHPO), and they have been assigned both Alaska Heritage Resource Survey (AHRS) and Forest Service (FS) numbers. There are also several additional sites known to exist, but are not inventoried. Sites not yet inventoried have not yet been reported to the SHPO and do not have AHRS numbers. Summary data about these sites are provided in Table 13. Among these areas are the high-altitude areas around Gilpatrick Mountain and Devils Creek. Since 99 percent of the landscape assessment area remains unsurveyed for cultural resources, there is obvious potential for finding many others sites.

Table 11. Cultural site types in the landscape assessment area

Site Type	Number of Sites
Historic Sites	46
Prehistoric Sites	2
Multicomponent Sites	1

Table 12. National Register eligibility of cultural sites in the landscape assessment area

Type of National Register Determination	Number of Sites
Cultural Sites Listed on the NRHP	0
Cultural Sites Determined Eligible for the NRHP	6
Cultural Sites Determined Ineligible for the NRHP	2
Cultural Sites Not Evaluated for NRHP Eligibility	41

NRHP = National Register of Historic Places.

Table 13. Known cultural sites not yet inventoried

Site Name	Drainage	Site Type
Yellowjacket Prospect	Quartz Creek	Historic
McMillan Prospect	Quartz Creek	Historic
Slate Creek Prospect	Slate Creek	Historic
Harry Johnson Summit Creek Cabin Remains	Summit Creek	Historic
Apex Prospect	Summit Creek	Historic
Summit Prospect	Summit Creek	Historic
Ronan-James Mine	Summit Creek	Historic

Recreation

In comparison with other areas on the Seward Ranger District, recreation use is relatively high in the assessment area. Recreation in the watershed is concentrated along established routes (the highway, trails, and waterways) during both summer and winter use seasons. These routes lie in valley bottoms, river corridors, and across bodies of water. The existing recreation facilities in the Quartz Creek Watershed are presented in tables 14, 15, and 16.

Table 14. Recreation trails located in the Quartz Creek Watershed

Recreation Trails	Length in the Quartz Creek Watershed (miles)
Carter Lake Trail	0.50
Crescent Creek Trail	5.70
Crescent Lake Trail	7.90
Devils Creek Trail	8.10
Old Sterling Highway Trail	5.02
Slate Creek Trail	1.87
Summit Creek Trail	3.30

Table 15. Recreation cabins and campgrounds located in the Quartz Creek Watershed

Recreation Cabins/Campgrounds	Location
Crescent Saddle Cabin	Southeast end of Crescent Lake
Crescent Lake Cabin	Western end of Crescent Lake
Quartz Creek Campground	Northern end of Kenai Lake near the Sterling Highway
Crescent Creek Campground	Near the Crescent Creek Trailhead

Table 16. Recreation sites located in the Quartz Creek Watershed

Recreation Sites	Location
Tern Lake Wildlife Viewing and Picnic Area	Adjacent to Tern Lake at junction of Seward and Sterling Highways
Quartz Creek Boat Launch and Quartz Creek Beach	Northern end of Kenai Lake near the Sterling Highway
Jerome Lake Interpretive Sign	Mile Marker 38.6 of the Seward Highway

Trails

There are seven recognized Forest Service trails or trail portions in the Quartz Creek Watershed (see figure 2). Only portions of the Carter Lake Trail, Devils Pass Trail, Summit Creek Trail, and the Old Sterling Highway Trail are located within the Quartz Creek Watershed. The Crescent Creek Trail is high use; the Crescent Lake Trail is a moderate/low use trail—both are multi-use trails contained entirely within the watershed. The Slate Creek Trail is a low use recreation trail and is also entirely within the watershed. Tables 17, 18, and 19 contain recreation use data for the trails monitored by the Forest Service within the Quartz Creek Watershed.

Table 17. Trail register count totals, 2008

Trail	Groups	People	Biking	Hiking	Horse	Fishing/ Hunting	Skiing	Snow Mach-ining	Over-night
Carter	314	852	2	221	0	88	2	1	60
Crescent	354	1,047	69	198	2	74	5	0	102
Devils	225	510	38	185	0	8	1	0	66
Summit	154	366	0	121	0	32	1	0	46

Table 18. Trail register count totals, 2007

	Groups	People	Biking	Hiking	Horse	Fishing/ Hunting	Skiing	Snow Mach-ining
Carter	376	907	1	278	0	93	3	1
Crescent	284	723	61	170	1	50	2	0
Devils	224	528	32	167	2	20	3	0
Summit	119	285	0	102	0	17	0	0

Table 19. Trail register count totals, 2006

Trail	Groups	People	Biking	Hiking	Horse	Fishing Huntin g	Skiing	Snow Mach-ining
Carter	335	758	1	284	0	43	5	2
Crescent	239	603	51	175	0	14	0	0
Devils	135	308	25	105	0	2	3	0
Summit	130	304	2	199	0	21	0	0

Recreation staff estimates only 33 percent of the visitors using a trailhead on the Seward Ranger District actually register. Typically, horseback riders, bicyclists and snowmachiners do not register at Forest Service trailheads. However, it can be assumed that the same number and types of users register across the district. Therefore, use numbers should be adjusted accordingly when estimating actual use of a trail.

As indicated in the tables, the use data for the four trailheads in the assessment area support the assertion that recreation use is moderate in the watershed. Additionally, use levels have not increased over this 3-year period. High use areas on the Seward District have over 1,500 users registering annually at trailheads. Further, these areas also have developed recreation opportunities such as campgrounds and cabins. A high use area on the Seward Ranger District can be found in the Russian River Watershed. In addition, no trail data exists for Crescent Lake Trail, Old Sterling Highway Trail, or Slate Creek Trail, which are not monitored.

Trail Descriptions

Carter Lake Trail. Only a short section of this trail lies within the watershed. The Carter Lake Trailhead is located at milepost 34 of the Seward Highway and has a paved parking lot (ten vehicle capacity), bulletin board, trail register, and vault toilet. The trailhead is plowed during the winter and overflow vehicles sometimes park at the Johnson Pass South Trailhead.

Crescent Lake Trail. Crescent Creek Trail starts from the Carter Lake Trail junction to the Crescent Creek Trailhead via the Crescent Lake Primitive Trail, which includes the Crescent Saddle Cabin. Summer access is difficult from this trail to the west end of Crescent Lake on the primitive trail. The creek crossing on the north end of Crescent Lake does not have a bridge and can be difficult to cross after rains. The primitive trail around Crescent Lake is not recommended for children, horses, and bikes due to difficult trail, tall grasses, and brush that obscures travel. Winter travel is not recommended and may be hazardous due to avalanches, thin lake ice, and white-out conditions above tree line.

Crescent Creek Trail. Located at milepost 3.3 of Quartz Creek Road, which is located off the Sterling Highway. The Crescent Creek Trail leads to the west end of Crescent Lake and is especially popular with families due to its gentle terrain and excellent trail conditions. Nine miles of primitive trail connect the two ends of Crescent Lake along the lake's south side. This trail is very popular in the summer months with hikers, mountain bikers, horseback riders, and anglers. Avalanche terrain makes this trail hazardous in the winter and spring due to the deep, dense snow in the avalanche paths.

Devils Creek Trail. Devils Creek Trail is on the west side of Seward Highway at milepost 39. Hiking, mountain biking, and horseback riding are common in the summer. The trail is well maintained in the summer though it may be wet and muddy in places. This route is closed to motorized vehicles to mile 3 year-round. Beginning in the 2007/08 winter season, motorized use was allowed December 1 to April 30, alternating each year on the remainder of the trail with access from the Resurrection Pass Trail.

Summit Creek Trail. This trail is located at milepost 39.5 of the Seward Highway, just south of Upper Summit Lake. Summit Creek Trail receives lower use than most of the trails on the Seward Ranger District. The trailhead is not marked with a sign on the highway and contains a small parking area with a trailhead bulletin board. This trail is popular with hikers seeking quick access to the alpine and the Resurrection Pass Trail. This trail is not recommended to horseback riding or mountain biking and is closed to snowmachine use during the winter.

Old Sterling Highway Trail. A sign marks the start of the Old Sterling Highway Trail at the west end of the Tern Lake Day Use Area near the intersection of the Sterling and Seward Highways. The trail runs west for about 5 miles and ends at the Quartz Creek Road near the Crescent Creek Trailhead. This is an off-highway route along the south side of the Quartz Creek Valley near Cooper Landing; there is a discrepancy in the Forest Plan on whether it is a road or a trail. It is used by both motorized and non motorized users year round, including hiking, biking, horseback riding, snowmachining, dogsledding, and skiing. The entire length of the road/trail is 5 miles and no use data has been collected.

Slate Creek Trail. The 1.9-mile Slate Creek Trail begins at milepost 42.7 of the Seward Highway Trail; there is an unmarked road and small parking area, and no trail sign or developed trailhead. Slate Creek Trail was constructed with equipment as a mining road.

Public Use Cabins/Campgrounds

Public Use Cabins. The Quartz Creek Watershed contains the Crescent Saddle and Crescent Lake public use cabins. These cabins can be rented for a fee of $45 per night (at the time of this publication). Cabin users can hike to the cabins or can contract with a flight service to provide access to these cabins. Crescent Saddle Cabin is located on the southern shore of Crescent Lake in the Kenai Mountains and is accessible by trail (11 miles from Crescent Lake Trailhead; 7.5 miles from the Carter Lake Trailhead) and floatplane. There is limited winter and spring access via Carter Lake Trail due to avalanche hazards on Crescent Lake Trail. Crescent Lake Cabin is located on the northwest tip of Crescent Lake in the Kenai Mountains and is accessible by trail (6.5 miles from Crescent Lake Trailhead) or floatplane. Winter access is not restricted.

Although access is more difficult to the Crescent Saddle Cabin, both of these cabins receive a high amount of summer use. Cabin use levels are shown in table 20. The predominate reasons recreation users visit the Crescent Saddle and Crescent Lake Cabins is for fishing, hiking, scenic quality, and hunting.

Table 20. Cabin use levels during 2001–2003 and 2008–2009

Cabin	Level of Visitor use	2001 (Jan.1-Dec. 31)	2002 (Jan.1-Dec. 31)	2003 (Jan.1-Dec. 31)	2008 (Jan.1-Dec. 31)	2009 (Jan.1-Sept. 22)
Crescent Saddle Cabin	Reservations	69	72	79	77	65
	Visitors (%) Instate/Out of State	N/A	N/A	N/A	272 82/18	239 85/15
Crescent Lake Cabin	Reservations	130	114	130	104	90
	Visitors (%) Instate/Out of State	N/A	N/A	N/A	391 94/6	365 93/7

*Data not available for 2004–2007.

Campgrounds. The Quartz Creek Campground contains 45 sites and is located on Kenai Lake in Cooper Landing, approximately 100 miles south of Anchorage, Alaska (by car). The campground contains water, dump stations, flush toilets, tables, and a boat launching area. The campground will include more upgrades in the future including an RV dump station, picnic sites, and an interpretive pavilion.

The Crescent Creek Campground contains nine sites and water, toilets, and tables. This campground is located at mile 3 of the Quartz Creek Road at the confluence of Crescent and Quartz Creeks.

Table 21. Campground use levels, 2004–2007

Campground	Level of Visitor Use	2004	2005	2006	2007
Quartz Creek Campground	% Overall Occupancy	72%	69%	69%	71%
	Total Number of Campers	13,469	13,926	12,434	13,840
Crescent Creek Campground	% Overall Occupancy	59%	50%	53%	49%
	Total Number of Campers	1,724	1,519	1,822	997*

* There was a problem with the consistency of data collection by the campground host.

On average, the Quartz Creek Campground is occupied about 70 percent and Crescent Creek Campground is occupied roughly 53 percent of the 153-day operating season. During the main salmon fishing season the Quartz Creek Campground registers at full capacity, because it is located near the Kenai and Russian Rivers. There are potential limitations to the campground data, because it is collected by campground hosts and there is no cross-checking or verification system. The level of competency and consistency varies with location and year.

There are at least four designated dispersed campsites in the Quartz Creek Watershed. Two are located near the end of the Carter Lake Trail, one is located along the Crescent Creek Trail, and one is located along the Devils Pass Trail. These sites are located at favorable locations along the trails (by lakes or creeks). The sites are identified by a camping post. Maintenance crews have developed tent pads, fire rings, and removed hazard trees at these sites.

Forest Service Recreation Sites

Jerome Lake. Jerome Lake is located at milepost 38.6 of the Seward Highway (0.5 miles north of Seward Highway/Sterling Highway junction), within the Quartz Creek Watershed. There is a paved turnout west of the highway. The ADG&F stocks the lake with Dolly Varden and rainbow trout.

Tern Lake Wildlife Viewing Day Use Area. Tern Lake Wildlife Viewing Area is located at the intersection of the Seward and Sterling Highways, at milepost 37 of the Seward Highway. The area provides visitors to the Kenai Peninsula an excellent opportunity to view a diversity of Alaska wetland birds and animals. Located along the Seward Highway, the site features an accessible viewing platform and interpretive signs. Throughout the summer, the Tern Lake Viewing Area is often staffed by a forest interpreter who can answer questions and help spot wildlife. Tern Lake Campground closed in the late 1990s during the budget cuts and flooding. However, there is still a viewing area over the outlet of the lake and a small parking area with toilets and trash receptacles. The Forest Service has recently completed a restoration project near the Tern Lake viewing platform. The purpose of the project was to restore stream habitat in Daves Creek near the Tern Lake outlet, and to enhance stream access and fish viewing in the area for a variety of users.

Quartz Creek Beach. A day use area with access to the Kenai Lake as well as Quartz Creek. The area has a sandy beach and is popular with recreationalists. There is one bathroom and a boat ramp with access to Kenai Lake. Camping and fires are not allowed.

Seward Highway

The Seward Highway, constructed in 1951, is one of the most scenic highways in the country. It was designated a National Forest Scenic Byway in 1998, and an All-American Road in 2000. It is one of 15 roads recognized for outstanding scenic, natural, historic, cultural, archaeological and recreational qualities in the Nation.

Sterling Highway

The 142-mile Sterling Highway, constructed in 1947 and completed in 1950, is part of Alaska Route 1, leading from the Seward Highway at Tern Lake Junction 90 miles south of Anchorage, to Homer. It is the only highway in the western and central Kenai Peninsula, and most of the population of the Kenai Peninsula Borough lives near it. The highway also gives access to many extremely popular fishing and recreation areas, including the Kenai and Russian Rivers.

Special Use Authorizations

Outfitter and Guide Commercial Use. In 2009 there were 46 outfitter/guide companies with permitted use in the Quartz Creek Watershed for a variety of activities including fishing, hiking, mountain biking, camping, horseback riding, scenic nature viewing, hunting, and float plane fishing trips to Crescent Lake. The Forest Plan outlines the capacity allocation for outfitter/guides for each management area. The management areas within the watershed typically allow for up to 50 percent of use to be guided use and 50 percent public non-commercial use. Table 22 summarizes the permitted and actual use for outfitter/guide companies by trail and activity during the summer season for 2005, 2006, and 2007.

Final use reports from outfitter/guides show actual use has been approximately 39 percent of permitted use in this watershed over the 3-year period (2005–2007), well below permitted allocation. From 2005 to 2007, Quartz Creek increased in popularity as a permitted location for guided fishing by commercial operators: 334 permitted days with 9 companies to 860 permitted days with 20 companies. However, the actual use of Quartz Creek decreased from 112 days to 102 days.

Table 22. Summer season guided use, 2005–2007

Trail or Creek	Permitted Use			Actual Use			# Guide Companies		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Quartz Creek (fishing)	334	709	860	112	155	102	9	19	20
Quartz Creek Area (horses and put-in for kayaking, etc.)	1,500	1,500	1,550	1,159	777	1,067	1	1	2
Crescent Creek Trail (biking)	203	234	234	39	19	44	4	4	4
Crescent Creek Trail (horses, llamas)	50	70	50	26	22	18	1	2	1
Crescent Creek Trail (hiking, camping)	400	397	393	18	8	12	8	8	8
Crescent Creek Trail and Lake (fishing and hunting)	304	419	528	51	85	42	9	12	14
Carter/Crescent Trails (skiing)	15	15	15	0	0	0	1	1	1
Carter Lake Trail (hiking, camping, canoe)	347	347	372	14	34	22	5	5	6
Carter Lake (llamas)	0	20	0	0	15	0	0	1	0
Carter Lake (fishing)	100	125	130	2	0	60	3	5	4
Tern Lake Day Use Area and Overlook	550	750	705	442	548	442	3	3	4
Old Sterling Lake Highway (bike, hike)	95	95	95	0	0	0	2	2	2
Resurrection Pass Trail, including Devils and Summit Pass (hiking, camping)	364	364	364	83	66	173	2	2	2
Resurrection Pass Trail, including Devils and Summit Pass (horses, hunting)	200	240	300	110	119	101	2	3	4

5. Reference Conditions

This section documents the knowledge of past conditions in the Quartz Creek Watershed. In order to understand the condition of the watershed and changes that have taken place, it is important to establish a frame of reference. For this analysis, the time frame for reference conditions varies based on times of important changes for particular resources. For some resource areas, little is known about changes over time, and proxy indicators are sought to help simulate what are thought to be reference conditions. In other cases, there are no good proxies for past conditions, and reference conditions may be based on knowledge of reference conditions of other watersheds, or knowledge of processes known to have taken place. Generally, reference conditions for the Quartz Creek Watershed are those conditions that would be present if the watershed were operating without significant human influence. It is also important to note that many of the changes in the watershed since reference conditions are the result of natural geomorphic change.

Lands

Note: All lands in the landscape assessment area were initially federally owned.

The reference condition is 1895, when people were utilizing the area for mining, hunting, fishing, and activities associated with subsistence use. Following the purchase of Alaska from Russia in 1867, the lands surrounding Prince William Sound became the focus of mineral exploitation (Alaskan.com 2000). An impending private monopoly on the reserves and transportation of its coal and copper motivated President Theodore Roosevelt to designate the lands of the CNF in 1907, originally some 23 million acres in size (Alaskan.com 2000).

During the 1960s and 1970s, outdoor recreation expanded exponentially nationwide. South-central Alaska's population rose from 50,000 in 1950 to 110,000 is 1970, and from then to 300,000 in 1985. Alaska residents continually seek recreation activities in a natural setting, while expanding tourism continues to attract many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960s and 1970s in response to the increased public demand.

During the last 40 to 50 years, various human developments in the area have greatly increased the number of people utilizing the Quartz Creek Watershed.

Geology and Minerals

Not relevant for this resource.

Soils

See the Landtypes discussion under the Watershed Characterization section.

Hydrology

Glaciers

Episodes of extensive glaciation and recession have occurred in south-central Alaska in the past 2 million years, with the last peak of glaciation occurring in the late Pleistocene (20,000 to 25,000 years ago), when glaciers filled the main valleys of the Quartz Creek Watershed. Large valley glaciers flowed from the north, near Summit Lakes, and a portion of the Trail Glacier flowed into the Quartz Creek valley from the east through the low pass separating Upper Trail Lake and Tern Lake. Rapid melting occurred in the Holocene, beginning about 12,000 years ago, accompanied by numerous episodes of small advances and retreats. The last glacial maxima occurred during the Little Ice Age, but only small alpine glaciers existed in the watershed at the time. By the early 1900s, glaciers were mostly absent from the watershed, although small remnant glaciers likely existed in many of the high elevation, north-facing basins.

Stream Channel

Stream channels in the Quartz Creek Watershed during reference conditions functioned entirely under natural processes. Alpine glaciers were more substantial in areas such as the Upper Daves Creek Basin than under current conditions, and glacial processes likely had a larger effect on stream channel processes than they do today. These small glaciers likely caused moderate levels of suspended sediment, moderate bedloads, and moderate degrees of channel dynamics in some streams; while other streams such as Crescent Creek were unaffected by glaciers because of the presence of lakes that capture glacial sediment. Streamflows were higher during periods of glacial recession than they are today as a result of the net loss of ice from the glaciers. Streamflows may have been slightly higher in the early 1900s than they are today because of the higher percentage of the watershed covered by glaciers.

Riparian vegetation played an important role in stabilizing stream banks. Stream banks were unaffected by human uses, but natural bank erosion was common as a result of channel migration and meander formation. However, it is likely that stream channel types in the early 1900s were similar to those that exist today.

Climate

Prior to the early 1900s, it is likely that the climate was slightly colder than it is today. The trend of climate change that we are experiencing today that can be attributed to emissions of greenhouse gases was not occurring during reference conditions. However, the global climate was in a state of warming after the Little Ice Age.

Vegetation and Ecology

No real data are readily available on reference conditions for vegetation; assuming reference vegetation conditions should be considered as those predating European settlement. Langille's (1904) "The Proposed Forest Reserve on the Kenai Peninsula Alaska" describes the conditions around the early 1900s. Langille's description portrays the entire Kenai Peninsula and provides some information about past anthropogenic disturbances. The disturbances described in this publication are logging and human-caused fires.

Regarding natural disturbances, Langille says, "Along the bay shore 40 to 60 percent of the older standing trees are dead, and on the high plateau 80 to 100 percent are dead but still standing, having evidently all died about the same time." (Langille 1904, page 10). This would most likely be the result of a spruce bark beetle (*Dendroctonus rufipennis*) outbreak. The scale at which this disturbance occurred is unknown.

The Earth's climate is constantly changing in ways that scientists are not able to reliably predict. Also, "plant interactions observed at any time are unique to the climate as well as the species" (Oliver and Larson 1996). Since plants migrate independent of one another in response to climatic shifts (Oliver and Larson 1996), it is impossible to predict what changes may occur in plant communities as climate changes occur. The best way to respond to potential changes in the future is to manage for the maintenance of diversity of plant species.

Botany and Weeds

The reference period for botany is considered to be the time before European settlement of the area. Very little information is available from that period. A few reports describe vegetation conditions that are similar to current conditions. The current conditions for sensitive plant species are expected to be similar to those of the reference period.

Over a longer time period, the vegetation and flora of this area have varied with changing climatic conditions. A recent paleoenvironmental study (Jones et al. 2009) provides a description of the climate and vegetation of the Kenai Peninsula over the past 14,000 years. The authors emphasize the regional variation they found across the Kenai during most time periods. A very brief summary illustrates the amount of climate and vegetation variation that occurs over time. Shortly after deglaciation, around 14,000 years before present (BP), peat formation began, suggesting that nearby areas remained unglaciated and served as refugia for vegetation during the glacial maximum. Around 11,500 BP there was a significant climate change. From 11,500 to 10,700 years BP the area was wetter; from 10,700 to 8,500 years BP the climate became drier. Around 8,200 years BP conditions became cooler and wetter; around 5,000 years BP volcanic activity increased, corresponding with drier conditions. Glaciation was again widespread by 1,500 years BP, accompanied by a cool, moist climate (Ager 1999). The modern vegetation seen in the assessment area developed in approximately the past 2,500 years (Ager 1999). This vegetation is a rich mix of boreal and coastal tree, shrub, and herb species. The area around Tern Lake marks a rather abrupt transition boundary between the maritime climate of the eastern and southern coasts of the Kenai Peninsula and the more continental climate of the Kenai Lowland and northwestern Kenai Mountains (Ager 1999).

Each of these climate changes resulted in different vegetation patterns. The glacial record suggests that a portion of the Kenai Peninsula remained ice-free during the last glacial maximum and harbored a number of species that were able to relatively rapidly colonize deglaciated sites. Spruce species were rare on the Kenai before 8,500 BP, though they may have been present in interior Alaska or in refugia on the Kenai during the glacial maximum. The species did not become common until after 5,500 years BP. Ferns dominated certain areas in the early Holocene; at other times shrubs or herbaceous species were the dominant plants (Jones et al. 2009).

The main difference from the reference period is the current existence of invasive nonnative plants in the assessment area. Nonnative plants were likely introduced as soon as European settlers began arriving in Alaska, but introductions from that period are not documented. Baseline conditions for nonnative plants in Alaska can only be established from 1941 when the first comprehensive flora of Alaska was published. Carlson and Shepard (2007) note that 154 weeds were recorded in Alaska in 1941.

Fire and Fuels

Fire occurred in the Kenai Mountains during the past century; but whether fire is the important disturbance process creating structural and landscape diversity within this ecosystem is unknown. There are three distinct areas of fire frequency: prehistoric (pre-1740), settlement (1741–1913), and post-settlement (1914 to present).

Prehistoric. The evidence for prehistoric fire events on the forest from radiocarbon dates on soil charcoal range from 4,500 years before present (BP) to 570 BP (Reiger 1995). Historical evidence supporting a climax forest is cited by Langille (1904) and Holbrook (1924). Both concluded from evidence indicated by old logs and decayed stumps of large size, that a prehistoric forest of greater proportions once existed, probably destroyed by fire before the Russian occupancy of the region. Although large historic fires were recorded on the Forest during the settlement period, we do not know how this compares with the number and size of fires during prehistoric fire history.

Settlement. Beginning in the late 19th century and continuing through the early 20th century, fires were frequent on the Kenai Peninsula. Perhaps the earliest written occurrence of Russian occupancy on the Forest was in late 1793 (Pierce 1983). Russian shipbuilders prospected in the Kenai Peninsula Mountains for iron ore; the ore was transported down along Resurrection to the bay.

The coming of the American gold seekers saw the first use of the forests, where the forests were exploited for lumber to build sluice boxes (Langille 1904). Many of the gold seekers were careless with fire, burning not only a large part of the timber, but their cabins and outfits as well (Holbrook 1924).

Foresters' diaries early in this century describe extensive fires on the Forest from 1913–1915. Railroad activity ignited 95 fires between 1932 and 1953 (Chugach NF fire history data). Drought conditions following the 1912 Katmai Volcano eruption also contributed to fire behavior, creating favorable weather for burning. Holbrook (1924) reports "the region has been visited by numerous fires and most of the better grade of timber has been burned". He mapped approximately 30,000 acres of burned area on the Forest. Some of these large, disastrous fires occurred in the Resurrection Creek Watershed, including the fires near Hope—namely Cripple Creek, Bear Creek and Sunrise Fires (1904–1930)—burning a total of at least 6,000 acres.

Post-Settlement. Human impact on the Forest has varied and early impacts have been masked by those which came later. Fire report data from 1933 to 2006 show 69 documented responses to fire starts; the total number of ignitions during that time is thought to be higher than 69 due to the fact that fire suppression activities took place without the knowledge of State and Federal land agencies. Fire occurrence data show large fires have burned 26,238 acres in the watershed, the majority of which burned prior to formal record keeping. An average of 240 acres burned per year between 1900 and 2006. The majority of fire starts (60) are small fires under 0.1 acres in size along the travel corridors.

Air Quality. Air quality was of the highest quality prior to the settlement of the Kenai Peninsula.

Aquatic Species and Habitats

The Kenai Peninsula has been occupied by humans for approximately 3,000 years (Benke and Cushing 2005). The Kachemak Riverine culture are thought to be the first inhabitants; they were replaced by the Kenaize Indians, Athabascans of the Tanaina Tribe approximately 1,000 years ago (Boggs et al. 1997 [in Benke and Cushing 2005]). The Kenai was a major source of fish for the first Alaskans who established large summer camps to catch and dry salmon (Langdon 1987 [in Benke and Cushing 2005]).

Russian fur traders arrived around 1750, and Captain James Cook sailed into the mouth of the Kenai in search of the Northwest Passage in 1778. The United States purchased Alaska from

Russia in 1867. Gold was found near Cooper Landing in 1880 which spurred the first European American expansion and settlement of the peninsula. The construction of the Alaska Central Railroad in the early 1900s accelerated settlement by opening up the first gateway to the Kenai Peninsula.

Prior to 1900 fisheries within the Kenai and Quartz Creek Watershed were probably in a relatively pristine condition, with an abundance of salmon, trout, and char. The extent of settlements and length of occupation by the Kenaitze indicate salmon runs were consistently reliable throughout the Kenai and Quartz Creek Watersheds (USDA Forest Service 2004). From the 1920s through the 1950s, variations in salmon escapements were likely impacted by commercial over-fishing, fish traps, and natural fluctuations in ocean productivity. The Sterling Highway improved access in the late 1930s to Quartz Creek, thereby increasing access to rainbow trout, Dolly Varden, and salmon. In 1947 the Kenai and surrounding areas were opened to homesteading. Since that time, recreation, especially fishing, has attracted the majority of development.

Terrestrial Species and Habitats

Little is known about past populations of wildlife in the Quartz Creek Watershed, except that moose now inhabit the area, and were not in the area prior to about 1850 (Largaespada 2005). The presence of moose is likely due to extensive expansion of hardwoods from human-caused fires at the turn of the century. It is likely that other species that use hardwoods such as lynx and birds have increased, and possibly species such as brown and black bear that prey on moose. Historic hunting and trapping pressure by native people and the Russians has likely influenced populations locally.

Historic travel routes and trails in the watershed were likely in the same areas as today, but were more primitive and had less use.

Historic data on vegetation composition and structure are not available from the reference period. In other areas, and likely in this watershed, humans impacted vegetation by cutting trees to create homes and other structures, provide fuel, and started fires which reduced large trees and created more early-seral hardwoods.

Sensitive Species

No sensitive species are known to occur in the watershed.

Management Indicator Species

Moose. Very limited information is available to describe reference conditions for moose in the Quartz Creek Watershed. There is no evidence that moose were present on the Kenai Peninsula until 150 years ago (Largaespada 2005). Some sources indicate that prior to the turn of the century caribou were abundant on the peninsula. Caribou presently occupy the watershed, but there history there is unknown.

Mountain Goat. No quantitative data exists to indicate what reference conditions were for mountain goats in this watershed. Increased hunting pressure after initial European contact may have reduced mountain goat populations; however, mountain goat habitat has probably remained relatively unchanged. Warming conditions are likely increasing the extent of forested habitat higher on mountain slopes, which will decrease available alpine habitat for mountain goats over time.

Brown Bear. Data on reference conditions of brown bear is very limited to nonexistent. We assume that historic populations of brown bear were higher, and that European contact decreased brown bear populations through habitat loss, hunting, and defense of life and property (DLPs). However, the increases in fisheries and moose populations may have increased bear numbers. The more recent increase in fishing and recreation in the watershed has resulted in some habitat encroachment and increased DLP mortalities.

Species of Special Interest

Wolverine. Little to no data exists on reference conditions for wolverine. As with all fur-bearers, populations may have decreased after European contact due to the increase in hunting and trapping, and habitat encroachment by humans.

Northern Goshawk. No quantitative information exists on reference conditions for goshawks. Undoubtedly, goshawks have been impacted by the spruce bark beetle infestation, causing reduction in potential nesting habitat.

River Otter. No quantitative data exist for reference conditions. Reports from the 1920s indicate Peninsula-wide scarcities, probably a result of increased trapping pressure after European contact. It is unclear how recreation and increased human use may affect river otter populations.

Lynx. Quantitative data regarding reference conditions for lynx are nonexistent. Reports from the 1920s (Culver 1923) indicate lynx were widespread on the Kenai Peninsula. As with all fur-bearers, populations probably decreased after European contact due to the increase in hunting and trapping.

Marbled Murrelet. Quantitative data regarding reference conditions for marbled murrelet are nonexistent. Overall, the watershed appears warmer and drier than many of the other watersheds on the Seward Ranger District, and site quality tends to be lower. Assuming conditions over time have remained stable, the watershed has never provided high quality nesting habitat for murrelets.

Townsend's Warblers. Data on reference conditions are unavailable. Forest Service surveys from the late 1970s indicate that Townsend's warblers were the most abundant species in older forests and were not abundant in recently burned forests. European contact may have decreased Townsend's warbler populations if older forests were altered, but overall impacts on the population were probably minimal. Forest fires and the spruce bark beetle over the last 100 years have also reduced available habitat over time.

Gray Wolf. No data exists on reference conditions for gray wolf in this watershed. The wolf population more than likely suffered declines after the influx of European settlers, as hunting pressure of all fur bearers increased at this time. However, wolf populations may have increased with the increase in the moose population beginning 150 years ago.

Heritage

This section is not applicable to heritage.

Recreation

The time period associated with this reference conditions category is 1895. At that time there was no recreation use, as we know it today, occurring within the analysis area. However, people were utilizing the area for mining, hunting, fishing, and activities associated with subsistence use.

Recreation, in the form of leisure time off work, really did not occur until after World War II. Generally, nationwide and to some extent within the watershed analysis area, the thought of camping, hiking, and fishing for fun, instead of for subsistence, became more popular after 1942.

During the 1960s and 1970s, outdoor recreation expanded exponentially nationwide. South-central Alaska's population rose from 50,000 in 1950 to 300,000 in 1985. Alaska residents continually seek recreation activities in a natural setting, while expanding tourism continues to attract many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960s and 1970s in response to the increased public demand. The Quartz Creek Watershed was primarily used as a transportation route for early miners.

Various human developments in the area have increased the number of people utilizing the Quartz Creek Watershed. These developments include the Seward Highway and Sterling Highway, Crescent Saddle and Crescent Lake cabins, Quartz Creek and Crescent Creek campgrounds, Quartz Creek Beach and Boat Launch, Tern Lake Day Use Area, and general development in the adjacent communities of Cooper Landing, Moose Pass, and Anchorage.

6. Synthesis and Interpretation

Sections 4 and 5 address the issues and key questions presented in section 3; this section briefly summarizes the differences between reference and current conditions, and considers the key questions, especially those that can be influenced by management activities.

Lands

It is not likely that any lands currently held by private landowners or the State of Alaska within the assessment area will return to Federal ownership.

Geology, Minerals, and Soils

Geology and Minerals

The potential for locatable mineral (gold) development to occur in the analysis area is high in the northerly and southerly portions of the assessment area as delineated by Nelson and Miller (2000).

All public domain lands are open to mineral entry under the 1872 Mining Law unless specifically closed. Bona fide mineral development cannot be prohibited where lands are open to mineral entry. On lands open to mineral entry, mining claims can be located and the mineral resources can be developed. The statutes also provide for a mining claimant's rights to reasonable access for prospecting, locating mining claims, and developing the mineral resource. Such activities must conform to the rules and regulations of the Forest Service; however, those rules and regulations may not be applied so as to prevent lawful mineral activities or cause undue hardship on bona fide prospectors and miners (FSM 2810). The U.S. Geological Survey considers portions of the area to have moderately and most favorable mineral potential with identified resources.

The potential for mineral materials or common variety mineral development on National Forest System lands is high in areas proximal to roaded portions of the analysis area. Disposal of salable minerals disposal is discretionary.

Mineral development is often perceived as causing negative impacts to surface resources and conflicting with other uses of the land, but can be and is managed to minimize impacts. Besides laws and regulations, the Forest Plan provides additional protection for wildlife, hydrology, soils, and other resource values through standards and guidelines.

Soils

Reference conditions compare favorably to the current conditions in regards to mass-wasting. Although the overall extent of natural slope failures is unknown, there are no known management-caused failures. Non-glacial erosion processes other than mass-wasting are not known to be accelerated on Forest Service lands within the analysis area.

Even though the area involved is relatively small, glacial recession is having the most effect on the geomorphic surface and on soil development on Forest Service lands in the assessment area. This is expected to continue at an increasing rate in the future. Depending on how long formerly ice-covered ground has been exposed, after as little as 10 years to more than a century, soil changes will include lower bulk density, lower pH, changing soil chemistry, and other alterations due to chemical and biological weathering, precipitation of soil minerals and colonization by bryophytes and ruderal vascular species. Some of these recently exposed sites will eventually become prime colonization sites for weedy invasive species. If other disturbance, for example, erosion were to continue, then weed species will continue to occupy these sites and prevent or slow native plants from establishing.

The same drivers of glacial recession may cause the fire incidence rate to increase, which would increase the background soil erosion rate on most soil types and land types. If fire incidence accelerates greatly, soils that are currently carbon-sinks would become carbon sources.

The older timber harvests and the 245 acres recently managed are expected to continue to revert towards the reference condition, and will not be detectable from soil examination within 20 to 50 years. The gravel pit that is part of this managed acreage would naturally restore itself somewhat, but would still be identifiable 20 to 50 years out. Even with maintenance, some trail erosion would be identifiable.

Hydrology

Stream Channel

With increasing levels of human activities in the Quartz Creek Watershed over the last century, many human uses have impacted stream banks, stream channels, and water quality. Most of these impacts have occurred and continue to occur within close proximity of the established road corridors, while channel conditions in backcountry areas are relatively pristine. Without protective measures in place to prevent damage to stream channels, these impacts will continue to worsen. Some impacts may require reconstruction of the banks or restoration of stream channels to maintain naturally functioning streams and riparian areas, while other impacts may require less invasive management solutions. Restoration projects such as the 2009–2010 Daves Creek Restoration Project can restore stream channels and riparian areas to natural conditions similar to those of the reference condition.

Stream channel dynamics occurring today are similar to those that occurred during the reference period, but on a smaller scale. With shrinking glaciers, sediment production has decreased to some degree, and stream channels are likely becoming more stable. However, meander migration in low gradient streams such as lower Quartz Creek continues to occur, and large scale channel changes can occur in high gradient alluvial fan channels such as Upper Daves Creek. While these channel dynamics had no consequences to human populations in the reference period, they now pose a threat to human developments. Because of the current potential for extreme precipitation and runoff events, humans only have limited control of some of these natural channel processes.

Climate

Changes in climate over the last century have had and will continue to have an effect on hydrologic processes in the watershed. These changes are less severe than in other Kenai Peninsula watersheds in which glacial processes are more dominant. The current trend in climate change will continue to bring gradual long-term changes to hydrologic conditions as a result of changes in precipitation patterns, snowpack, glacial extent, and the condition of riparian vegetation. The magnitude of many of these impacts is unknown, and data are limited; however, the magnitude of climate change is increasing and will play a larger role in future management decisions.

Vegetation and Ecology

There is little data on historical conditions of vegetation in the Quartz Creek Landscape Assessment Area, but changes presently occurring to vegetation are readily observed. Anthropogenic alterations to the landscape and disturbances should be considered as the factors causing the most significant variation between current and reference conditions. Anthropogenic alterations and disturbance include management actions, development, invasive plant species, exotic insects and disease, and human-caused fires.

Management actions affect the landscape by changing the vertical and horizontal structure of vegetation. The effect this has is dependent upon the type of management action. Development has undoubtedly affected the landscape in promoting the spread of invasive plants—which may out-compete native plants and change the vegetative mosaic in the assessment area. Exotic insects and disease have not yet played a significant role in shaping the current landscape in the assessment area, but with the possibility of the introduction of extremely destructive species, such as Asian gypsy moth, exotic insects and disease should be considered as possible anthropogenic disturbance. Asian gypsy moth affects about 600 species of conifers (USDA Forest Service 2009) and a host of broad-leaved plant species. This exotic pest, which is indicated as a threat to Alaska, could cause widespread defoliation and possible mortality, especially within the context of synergism with other forest pests, thus creating significant alterations of the landscape.

Human-caused fires are probably the most significant anthropogenic disturbance agent affecting the assessment area. This disturbance, as observed throughout the Kenai Peninsula, has potential to create large areas of relatively homogeneous early-seral species. Examples of this can be seen near the community of Hope, Alaska, which has large areas of mature birch from human-caused fires that occurred in the early 1900s. Human-caused fires have the potential to create large patches of early-seral species that may last 100 years or more.

Botany and Weeds

Stand structure in this watershed is similar to many other large watersheds on the Kenai Peninsula. Except for high use areas such as roadways and developed areas, this landscape remains in fairly pristine condition. Much of the watershed (74 percent) is not forested but has large areas of rock, snow, ice, and grass and alpine communities. Although little information is available on vegetation during the reference period, the composition, structure and function of plant communities was probably similar to what exists today, with the exception of developed areas, recreation use, and the presence of nonnative plant species. Vegetation in some areas has been cleared for private land development, roads, trails, and facilities such as campgrounds. Vegetation composition and structure have been modified by fuel reduction treatments around communities and along transportation corridors and by wildlife habitat improvement projects in parts of the assessment area. The historic habitat types likely still exist within the assessment area and are available for establishment or spread of sensitive plants; the relative abundance of each type has probably changed somewhat in response to natural processes and anthropogenic activities. Under current conditions habitat for sensitive species is for the most part intact and pristine.

One change since the reference period is the amount of human use. Recreation use is particularly common in the vicinity of Crescent Lake near a population of Pale poppy, the one sensitive plant known to occur in the assessment area. This amount of use is undoubtedly a change from reference conditions and could adversely affect the population. Since the population occurs on slopes above the lake, most visitors would not venture onto the sites and disturbance is expected to be minimal.

The current outbreak of spruce beetle has led to an increase in standing and on the ground woody debris with areas of gaps in the forest canopy leading to an increase in early-seral plant species. This change in vegetation composition and structure will continue as the effects of the bark beetle infestation play out. Whether this outbreak is outside the historic range of variability is unknown due to the paucity of historic information, but the consequences under current conditions will likely be different from those under reference conditions, largely as a result of the presence of nonnative invasive plants in the landscape. The increase in incoming solar radiation coupled with increased soil disturbance creates optimal conditions for the invasion of nonnative plant species, especially when combined with historical and ongoing human disturbances in these areas. Nonnative plant species are closely associated with human disturbance and therefore, it is unlikely that these species existed in this area prior to human alterations of the landscape.

In much of the western United States, fire suppression has resulted in more dense forest stands. In the assessment area, forest stands are dominated by tree species that typically have fire return intervals of several hundred years. For that reason, fire suppression may have had less impact than in areas typically supporting frequent fires.

Villano and Mulder (2008) found that in some locations, roadside populations of nonnative plants are invading areas burned by wildland fires. Sites had different levels of susceptibility to invasion, with human use being the most important factor influencing the spread of nonnatives. But human use and climate did not explain all the variation among sites. Some areas of high use did not have nonnative infestations. They suggest further research, but speculate that soil pH and bryophyte cover may influence invasion at some sites.

In the past, many ecologists and botanists have considered Alaska to be immune to invasion of nonnative plants due to its isolation, relative lack of disturbance, and cold climate (Carlson and Shepard 2007). However, invasive plants are now common along roads and in disturbed areas, and in some cases have invaded natural ecosystems. Once weed populations have become established, they often persist for some time without dramatic expansion. During this lag phase, they are susceptible to extirpation. After persisting at low levels for years or decades, populations may enter a phase of dramatic increase, sometimes expanding exponentially. Treatment during this phase is much more difficult and expensive.

Changes in climate may have a profound effect on this assessment area in the future. Alaska is experiencing changes as a result of temperature increases (ACRC 2009) and those changes may already be affecting vegetation patterns in the assessment area. Changes are expected to be complex, local in nature, and difficult to predict. Some models predict more winter precipitation for Alaska (SNAP 2008) which could mean more snow pack, but earlier melting, resulting in less accumulation. Changes in the timing, duration, thickness, and distribution of seasonal snow may significantly impact many aspects of the hydrological cycle including surface runoff, groundwater recharge, and river streamflow. Rising temperatures contribute to glacial retreat, earlier spring runoff, reduced sea ice, and permafrost thawing. Permafrost warming has resulted in coastal erosion and disruption and damage to forests, structures, and land subsidence (Brown and Romanovsky 2008). Some areas are experiencing expansion of boreal forests (Lloyd et al. 2003) and significant increases in forest fires and insect outbreaks (ACCS 2009). Wetland drying appears to be accelerating on Kenai lowlands (Klein et al. 2005). The ultimate consequences of these changes in climate cannot be accurately predicted at this time, but should be considered when planning future management activities.

Aquatic Species and Habitats

The Quartz Creek Watershed contributes to one of the most productive fisheries in the world and the most economically important river systems in Alaska—the Kenai River. There is little information regarding estimates of salmon run sizes pre-European American settlement compared to those of today for the Kenai River (and hence, Quartz Creek). The Kenai River and Quartz Creek Watershed and tributaries have been impacted by highway and road and trail construction, angling pressure, land development and mining, and recreation facilities such as campgrounds. However, the Kenai River system was found to produce 2.3 times as many salmon per unit length of river when compared to the Deshka River in south-central Alaska (Dorava and Scott 1998). In addition, since the 1960s salmon run sizes within the Kenai River have remained relatively stable and are thought to be within the natural range of variability with normal fluctuations in populations due to ocean survival and cyclical environmental factors. Therefore, it appears that fisheries management has been successful and habitat impacts due to development of the watershed have been relatively incremental and have not significantly altered aquatic habitat or fisheries production.

Competent fisheries management has been integral to the sustained fisheries and productivity of both the Kenai River and Quartz Creek Watershed. Maintaining escapement of adult salmon to return to spawn is not only critical to maintaining stable, harvestable populations of salmon, trout, and char, but is vital to the nutrient cycling and overall productivity of the watershed, including wildlife. Returning salmon bring millions of pounds of marine-derived nutrients such as carbon, nitrogen, and phosphorus into the watershed. Salmon carcasses provide the aquatic ecosystem with nutrients fertilizing streams, lakes, and riparian areas. Brown and black bears on the peninsula are extremely dependent on the returning salmon and help deliver nutrients to riparian areas and terrestrial habitats by dispersing carcasses during consumption and defecation (Hilderbrand et al. 2004). Studies on watersheds of the Pacific Northwest have shown that when salmon stocks are depleted and nutrients normally supplied by salmon are absent, productivity of the entire watershed is diminished (Bilby and Bisson 1996).

Conversely, some studies suggest that over-escapement of salmon, especially sockeye, can have deleterious effects to production. Excessive sockeye spawning escapements may produce more rearing juveniles than can be supported by the nursery lake (Kyle et al. 1988). In general, when juvenile sockeye abundance and density greatly exceeds the lake's carrying capacity, prey resources can become significantly altered by changes in species and size composition (Mills and Schiavone 1982; Koenings and Burkett 1987; Kyle et al. 1988) which produces a negative domino effect on all trophic levels (Carpenter et al. 1985). As the prey base becomes depleted by over population, growth of juvenile sockeye is reduced; mortality increases and larger percentages stay within the lake for another year of rearing. The combined effects of overpopulation within the lake produces smaller, less fit smolts which have significantly higher mortality rates when they immigrate to the estuary and ocean. When escapement levels exceed two to three times the normal levels, it may take more than a year for normal productivity to rebound. Juvenile sockeye from subsequent brood-years are impacted by both the poor quality, low quantity forage and from the increased competition for food by juvenile sockeye holding over in the lake (Townsend 1989).

The resiliency of the Kenai/Quartz Creek ecosystems and high productivity is due mostly to the relatively undeveloped nature of the watershed and the network of intact, healthy condition of riparian areas, wetlands, lakes and tributary streams. The availability of high quality overwintering habitat such as lakes and beaver ponds are critical to the survival of juvenile salmon and overall production of smolts (Tschaplinski and Hartman 1983; Reynolds 1997). Therefore, protection of fully functioning, high quality undisturbed areas of the watershed are priority, and the protection, restoration, rehabilitation, and enhancement of overwintering habitat within the Quartz Creek watershed is paramount. Spawning habitat and other reaches of stream that have been disturbed by natural or anthropogenic causes should also be rehabilitated or restored to maximize aquatic invertebrate and fisheries production.

Aquatic invasive species are potentially the greatest threat to the aquatic resources within Quartz Creek and the Kenai River Watersheds. Currently, ADG&F Sport Fishing Division consider northern pike and Atlantic salmon the two greatest fish species of concern in Alaska. Northern pike are rapidly spreading throughout south-central Alaska and considered the highest priority threat by the Sport Fishing Division biologists. Northern pike are voracious predators and when introduced eliminate or greatly reduce native fish populations. Pike were introduced into the Susitna River drainage in the 1950s and since have severely reduced populations of rainbow trout, arctic grayling, and coho salmon. They have the potential to severely impact the Kenai River and Quartz Creek ecosystems and could do irreparable damage to the regional economy.

Atlantic salmon also pose a significant threat to the Kenai River and Quartz Creek ecosystems. Atlantic salmon, if they become established, would directly compete with native fish such as Chinook and coho salmon for food and hiding cover habitat.

Yellow perch were recently eradicated from the Kenai Peninsula. If this species had become established on the Kenai Peninsula, impacts to salmon, trout, and char populations could have been severe (Fay 2002).

Additional aquatic species of concern which have not been detected in the basin to this point, are the New Zealand mud snail (*Potamopyrgus antipodrium*), signal crayfish (*Pacifastacus leniusculus*), and the spiny water flea (*Bythotrephes cederstroemi*). The New Zealand mud snail is a small aquatic snail that can be easily transported via waders and wading boots, and poses a serious threat to Alaska sport fisheries. This species can propagate to extreme densities (one-half million per square meter) which can severely alter the food chain for native fishes. The signal crayfish has been found in streams on the coast of British Columbia, Canada. Once established this species usually becomes the dominant component of the streams biomass because it eats everything (plants and animals) available to it and directly and indirectly compete with native fish populations for food. The spiny water flea is a cladoceran (a small aquatic crustacean) from Europe which is also typically transported on fishing gear such as waders. Spiny water fleas are now found in the Great Lakes region and California. This invasive species displaces zooplankton populations, but is unpalatable to fish such as sockeye salmon. If introduced, this species would pose a serious threat to the sport and commercial sockeye fisheries supported by the Kenai River/Quartz Creek systems.

The invasion of non-indigenous species costs governments of the world billions of dollars annually and has significantly impacted ecosystems, industries, and human societies. The fisheries produced by the Kenai River Watershed, including Quartz Creek, support a significant percentage of south-central Alaska's economy. The potential for introductions of invasive species into the Quartz Creek and Kenai River Watersheds is very likely due to the sheer number of people who enter the Quartz Creek Watershed to fish and recreate and the demographic composition of visitors who come from all over the world. Therefore, prevention, early detection, eradication, or minimization of impacts of invasive species within the watershed is critical.

In 1999 Executive Order 13112 on Invasive Species called for increased coordination between Federal and State governments to combat nonnative (alien) species which introduction causes or is likely to cause harm to human health, the economy, or ecosystem. The ADF&G has developed an aquatic nuisance species plan to minimize their impacts to marine, estuarine, lake, and river environments.

Terrestrial Species and Habitats

Threatened, Endangered, or Sensitive Species. The watershed currently does not have threatened, endangered, or sensitive wildlife species or habitats, and it is unlikely that they occurred in the watershed during the reference period because these species are marine mammals or birds.

Management Indicator Species

Changes in brown bear populations are unknown. As stated earlier, populations likely declined through habitat loss, hunting, and defense of life and property (DLPs), but potential increases in fisheries and moose populations could have increased bear numbers as well. Increasing recreation in important habitat areas can cause disturbance, habitat avoidance, or increase the potential for bear human interactions. Recreation (fishing, camping, hiking, mining) is occurring in foraging areas along anadromous streams in Quartz Creek and Daves Creek, in the core area along the Carter Lake Trail, near denning sites in the core area and in the northern watershed (snowmachining and skiing). Highways are intersecting brown bear travel corridors or areas that are important for habitat connectivity. Climate change may affect bear prey species or habitats. Current populations and trends are unknown, but it is likely that with all the human-related pressures, bear populations are and will continue to be lower than during reference conditions

Mountain goat numbers may have been reduced with increased hunting pressure after initial European contact. Since then, with regulated hunting and management, and little development in alpine areas, goat habitat and numbers have probably remained relatively stable. Climate change may impact goats in the future by reducing habitat availability.

Moose may have increased after the turn of the century when human-caused fires created more habitat, but numbers are now stable to declining. Management continues to try to increase moose numbers for subsistence, recreation, and watchable wildlife. With this management emphasis, moose numbers will likely remain fairly stable over time. Spruce bark beetle impacts continue to open the canopy as more trees die, offering opportunities for hardwood browse to established.

Species of Special Interest

Fur-bearer populations of bear, wolf, wolverine, lynx, river otter, and other species may have decreased after European contact due to the increase in hunting and trapping, and habitat encroachment by humans. Since then, ADF&G endeavors to regulate population changes. Continuing human development, recreation, and roads will likely continue to affect individuals negatively, and climate change may have varying effects on these species and their habitats and prey species.

Other Species

Other species of interest include caribou and Dall sheep, unique to the Seward Ranger District on National Forest lands. Reference conditions indicate caribou may have been more abundant in the past. At one point they were extirpated and re-introduced. While caribou population trends are stable on the CNF, sheep populations have been declining (McDonough 2005). Reference conditions for sheep are unknown. Climate change will likely have negative effects on both species; if warming temperatures enhance encroachment of shrubs or forest into the alpine zone (see Climate Change).

Climate Change

Climatic changes have been occurring over the past several decades on the Kenai Peninsula. Data from the Moose Pass weather station show an increasing trend in temperatures since 1967 (see Hydrology sections). It is expected that this trend of increasing temperature will continue, but the magnitude of change over time is unknown.

Climate change has and will continue to have effects on the hydrology of the Quartz Creek Watershed, although the direction and magnitude of these changes are unknown. An estimation of changes that may have started to occur, or could be reasonably expected to occur in the future include:

- Continuing larger scale spruce bark beetle impacts on mature vegetation. Higher temperatures have likely caused the largest recorded spruce bark beetle impacts on the Kenai Peninsula. Bark beetle impacts will likely continue to affect primarily the large trees in the future. Loss of larger trees will continue to affect species that use them for nest structures such as northern goshawks and other raptors.
- Climate change will affect the distribution of vegetation types on the landscape over time. Forested areas may become more abundant and alpine and subalpine areas less abundant. Differences in vegetation cover types were compared between the timber type GIS layer (30+ years old) and the more recent vegetation layer developed by the Kenai Peninsula Borough (KPB 2007). Differences in the classification of snow, ice, rock, and barren areas were apparent. Even with some of the classification differences and differing levels of detail to which boundaries may have been drawn, some important monitoring concerns were identified. Many areas that were classified as “other brush” in the timber type layer (although “alder” was an option) are classified now by the borough as alder. This may be a classification error or an indication that the composition of species in the subalpine zone maybe changing. There are some areas now that were classified as alpine or grassland in the past that are now classified as alder, showing potential encroachment of shrubs in to these areas. In other areas, the alpine zone may have expanded.
- Changes in vegetation types and structures will affect wildlife habitat. Changes will benefit some species, and reduce habitat for others. In some cases new conditions may pave the way for range expansions or reductions, or exotic species introductions. Bears use a wide variety of vegetation types for traveling, feeding, resting, foraging, and denning. While bears may adapt fairly well to some of these changes, climate changes may have greater effects on some of their prey species such as fish which depend on certain water temperatures, and alpine or subalpine species such as mountain goats, Dall sheep, and marmots. Caribou would also experience loss of habitat. Forested habitats for species like northern goshawks and some migratory birds may become more abundant.

- Warming temperatures may cause the reduction of some snow and ice fields or glaciers due to melting. Although the extent of use is unknown, local reports from pilots and tour operators on glaciers (Godwin Glacier Dogsled Tours) indicate that some animals such as bears use snow fields or glaciers as regular travel routes. Caribou are known to use snow fields as refugia from insects in the summer. Some alpine species such as mountain goats appear to use snow fields to escape summer heat. As these areas decrease, there will be some effects on species that use them. The extent or significance of these effects is unknown.
- Warming temperatures may affect fish that depend on certain water temperatures for survival. Salmon in particular provide food at various stages to a wide variety of species and contribute to terrestrial nutrients. Warming temperatures may reduce suitable habitat for fish or change the species composition, creating a variety of effects on the wildlife species that depend on them for food.

Vegetation Composition and Structure Change

Prior to the beginning of the 20th century, vegetation communities were essentially pristine, affected only by natural disturbance regimes such as fire, avalanches, and seasonal flooding. Now, many areas of the watershed are affected by clearing vegetation for private land development, roads, trails, and facilities such as campgrounds. Vegetation composition and structure has also been modified for fuel reduction around communities and along transportation corridors, and to improve moose habitat by promoting early-seral hardwoods. The spruce bark beetle has had large scale effects on the Kenai Peninsula, killing many of the large mature spruce trees. Climate change may be altering the composition and structure across the landscape over time, potentially reducing the alpine zone and snow and ice fields while expanding forested and subalpine areas.

Habitat Connectivity Changes

A major change in conditions from reference to current conditions it the addition of two major highways in the watershed. Highways can cause barriers to some animals for traveling, and can cause mortality from vehicles.

The Sterling Highway bisects moose winter range; radio collared moose have crossed the highway and several moose are killed each year along this stretch of highway (Kain 2009; O'Leary 2009). A State trooper noted, however, that the area does not have as much mortality as other areas closer to Sterling and Soldotna.

Trooper records indicate 35 large animals killed on the Sterling and Seward Highways within the watershed from 2000–2009. Moose were the primary species hit, with a few black bears as well. Although no brown bears were recorded, ADF&G personnel noted that one to two brown bears were hit near Devils Pass Trail and one to two near Daves Creek in the last several years. Forest Service law enforcement noted one hit near Tern Lake several years ago. Higher vehicle collisions with animals at mile 40 and 43 of the Seward Highway and between miles 40–42 of the Sterling Highway may indicate travel corridors or areas of habitat connectivity.

The Seward Highway bisects important Dall sheep winter range and both highways bisect mountain goat winter ranges. If animals move from area to area at any time, they would at times have to cross the highways. The breeding season for mountain goats occurs between late-October and early-December. Billies (male goats) may travel considerable distances in search of receptive females (nannies). Many Dall sheep populations visit mineral licks during the spring and often travel many miles to eat the soil at these unusual geological formations. Some sheep could be killed crossing highways.

Table 23. Moose and bear hit on the highways from 2000–2010

	Mile of Seward Highway											
Year	**37.5**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**Total Animals**	**Total Moose**	**Total Bear**
2000		M [1]		M			M			3	3	0
2001			M			M			M	3	3	0
2002				BB [2]			M			2	1	1
2003				2 M			M	3 M	BB	7	6	1
2004							M			1	1	0
2005										0	0	0
2006			M	M		M	M			4	4	0
2007							M			1	1	0
2008	M			M	M					3	3	0
2009										0		
Total	1	1	2	6	1	2	6	3	2	24	22	2
	Mile of Sterling Highway											
Year		**38**	**39**	**40**	**41**	**42**	**43**					
2000						M				1	1	
2001				M						1	1	
2002				2 M	M					3	3	
2003										0	0	
2004					M	M	M			3	3	
2005										0	0	
2006					BB					1	0	1
2007										0	0	
2008										0	0	
2009				M		M				2	2	
Total			0	4	3	3	1			11	10	1

[1] = Moose.
[2] = Black bear.

Increasing Human Population

The watershed has been undergoing significant site-specific human disturbances over the course of the last 100 years. Prior to the beginning of the 20th century, vegetation communities were essentially pristine, affected only by natural disturbance regimes such as fire, avalanches, and seasonal flooding. Human-related disturbances include development, roads, and recreation.

Recreation activities include winter recreation (snowmachining, skiing, snowshoeing, fishing), and summer recreation (hiking, biking, flight seeing, fishing, recreational mining, and bird watching).

Hunting/Trapping: With greater numbers of people inhabiting the watershed, there is likely greater hunting and trapping pressure overall, although hunting and trapping are regulated by the State. How this has changed animal numbers or species composition from the past is unknown. Current management focuses on increasing moose numbers and will continue to do so.

Heritage

Effects of Human Use on Cultural Resources. The number of people visiting the watershed is expected to increase over time; this increase is focused on a smaller number of areas and access points than historically. Cultural resource sites and features are susceptible to many altering elements, which may adversely affect their integrity. Focusing the trail use can lead to additional direct and indirect effects that will need addressed. There are significant cultural resources that need documentation and protection. In addition, the probability of discovering additional historic properties is high within the assessment area. It is important to preserve our heritage, and to do this we must consider the effects that human use, as well as the environment, may have on these resources.

Recreation

General Observations. Outdoor recreation is the fastest growing use on the national forests and grasslands across the United States, continuing a steady trend since before the 1950s (Cordell, 2004). Population has continued to be the major driver of outdoor recreation participation growth in this country (Cordell 2004). The Kenai Peninsula Borough is one of the most populated and fastest growing regions of Alaska, and the rate of recreation growth on the CNF is likely to disproportionately increase the number of recreational users. Currently, well over 90 percent of Americans participate in at least one outdoor recreation activity (Cordell 2004). Estimates of recreation days occurring in forest settings from 2000–2001 show (in order) walking for pleasure; viewing/photographing natural scenery, birds, flowers, and wildlife; day hiking; sightseeing; driving for pleasure; mountain biking; and visiting a wilderness or primitive area (Cordell 2004).

Following suit with national recreation trends, recreation use in the Quartz Creek Watershed has increased since the 1950s. Various human developments including construction of the Seward Highway and the Sterling Highway, and the construction of the Quartz Creek Campground and Boat Launch have increased the number of people using the Quartz Creek Watershed. In addition, all of the trailheads in the watershed are easily accessed from the main highways.

Within the past 50 years, the concept of recreation itself has changed with the advancement of technology to include a wider range of recreation experiences. The development of new technology which is lighter in weight and more durable such as full-suspension mountain bikes, waterproof hiking boots and rain gear, synthetic clothing and sleeping bags, powerful snowmachines, four-season camping tents, backcountry telemark gear, and more versatile float planes have allowed recreationists to pursue new activities in the backcountry which are longer in duration and can be carried out year-round. New technology in the form of sport-utility vehicles, larger recreation vehicles (RVs) and large motor homes has changed the original concept of front-country recreation that was envisioned for the recreationists of the 1960s and 1970s.

Many of the Forest Service campgrounds, day-use areas, trailheads, and hiking trails built in the 1960s and 1970s are not adequate for today's recreationists, and have been or will eventually need to be upgraded, replaced, or rebuilt to conform to the needs and desires of today's recreationists and to comply with current Federal, State, and local laws, regulations, and guidelines. Many new facilities such as backcountry cabins, yurts, huts, campgrounds, and campground expansions are also being built, planned, or proposed on National Forest System lands to meet the increased demand for recreation.

The overall result of new or modified recreational activities and the increase in the number of recreation visitors to the Kenai Peninsula has led to many new opportunities and challenges. The large number of visitors using the Kenai Peninsula has contributed to and changed the economy of many Kenai communities, but has also contributed to the deterioration and loss of ecological and cultural resources and facilities. For example, foot traffic along the river banks can damage fish-rearing habitat, kill vegetation, compact and erode soil, impact wildlife, and damage tree roots.

Quartz Creek Watershed Area Recreation Trends. In general, an increase in outdoor recreation participation is assumed to be due to population growth. Alaska is also a destination location for many recreational enthusiasts from out of State, and Alaska residents are known for their propensity to recreate throughout the State. The Quartz Creek Watershed has continued to experience moderately high recreation demand, especially in the recreation areas that are located near the main travel corridors. It is expected that recreation will increase in the majority of the Quartz Creek Watershed beyond population growth rates. However, recreation demand along the road system could increase at a greater rate given the easier access to trailheads, campgrounds, and recreation sites.

Quartz Creek Area Recreation Conflicts. Generally, the main sources of recreation conflicts are adverse interactions between different user groups (i.e., mountain bikers and horseback riders) and occasionally between the same user groups (i.e., anglers). These conflicts can occur because recreation users feel crowded by other users or because different uses are perceived as incompatible. Examples of potential recreation conflicts in the Quartz Creek Watershed can include conflicts between: (1) bikers and hikers or bikers and horseback riders on the Crescent Creek Trail, (2) competition between anglers and commercial guides and public anglers along Quartz Creek, (3) lack of Forest Service cabins available to rent during the summer by short-advance planning visitors, and (4) lack of available developed campground sites for recreationalists.

7. Desired Condition, Opportunities, Management Strategies, Data Gaps, Monitoring and Research Needs

This chapter discusses desired future conditions, considering the differences between reference and existing conditions discussed in section 6. Desired future conditions consider what is feasible today and current management direction. Opportunities, management strategies, data gaps, and monitoring and research needs are presented for each desired future condition as means to achieve the desired condition.

The following incorporates management direction from the Revised Forest Plan (page 3-13) (USDA Forest Service, Chugach National Forest, 2002a).

Table 24. Opportunities, management strategies, data gaps, and monitoring and research needs for each desired future condition by resource

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
Lands			
There are no known property right acquisitions in the landscape area.			
▪There are always opportunities to acquire property rights on non-National Forest System lands; however, at present, there are no property right acquisitions that are desired by the Forest Service in the landscape area.	▪None identified.	▪None identified.	▪None identified.
Geology, Minerals, and Soils			
Geology and Minerals			
All lands not expressly withdrawn from mineral entry for campgrounds and similar developed sites are and should remain open to mineral entry. Continued use of 35 Mile Pit and RS&S rock source for disposal of mineral materials. Make additional areas available for disposal of mineral materials if a need is identified.			
▪The assessment area is open to mineral entry and location (locatable minerals) if not expressly withdrawn. Opportunities exist for development of sand, gravel, and rock, primarily in the roaded valleys to support local residents and local infrastructure projects.	▪Process locatable submittals promptly according to 36 CR 228A and FSM 2810 regulations. Consider all reasonable requests for Mineral Materials under 36 CFR 228C and FSM 2850 regulations.	▪Develop 10-year mineral material management plan for roaded areas of the Kenai Peninsula.	▪Investigate possible sites for development of mineral materials to support the needs of local residents and infrastructure construction and maintenance.
Soils			
Soil resources will be the result of natural processes. Soil resources will provide natural soil ecosystem functions, processes, and services such as soil organism habitat, biogeochemical cycles, watershed stability, water storage and release, and above and below ground biodiversity as compared to a natural reference.			
▪Work with other Forest programs, agencies, and landowners to manage soil resources to maintain or improve soil quality and function. Use models including WEPP, CENTURY, RAVE, SOIL, and others to predict, manage, and/or mitigate erosion, soil carbon, nutrient cycling, pesticide behavior and fate, movement of water, gases, and solutes associated with projects. Provide interpretations for uses, responses, resiliency, and restoration to support project design.	▪The assessment area lacks soil resource inventory of the FS National Hierarchical Framework of Ecological Units for the land type phase and soil units. Other existing inventory units including landtypes do not meet TEUI or NCSS standards.	▪Design projects to meet soil quality standards (SQS), soil and water BMPs, and mitigation prescriptions documented in ecological assessments (CE, EA, EIS). Watershed restoration activities will improve the characters and functions of the soil. Restoration activities for other resources will cause no harm or will cause net improvement to soil resources. Conduct land stability analysis as prescribed in appendix A.	▪Inventory, map, and monitor mass-wasting areas to determine baseline type and extent and rates of movement/change/effects. Monitor soil quality parameters associated with project design and implementation. Monitor vadose zone and wetlands associated with restoration for proper hydric soil classification and function. Model the soil carbon pool as a baseline monitoring reference for climate change.

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
Hydrology			
Water resource conditions will result primarily from natural conditions. Stream channels throughout the watershed will function naturally in terms of hydrologic function, bank stability, riparian condition, water quality, and aquatic habitat. Stream banks in high-use areas will remain healthy, with measures in place to restore damaged areas and to prevent additional bank disturbance from occurring. Streams and lakes of the watershed will have acceptable water quality, as defined by the Alaska State water quality standards (Alaska Department of Environmental Conservation 2006). Streamflows will remain sufficient to maintain natural hydrologic, riparian, and biological processes in streams in the watershed. Natural stream processes will occur, but controlled to protect human developments. Contributions to greenhouse gas emissions will remain limited, and riparian ecosystems will have high resiliency to the effects associated with climate change.			
▪Implement the construction of bank protection measures such as fences, boardwalks, and stream access stairways in high-use areas to protect banks and riparian vegetation. ▪Restore damaged stream banks along streams such as Lower Quartz Creek using natural materials in areas where angler trampling is causing increased bank erosion rates, water quality impacts, and impacts to the stream channel and habitat. ▪If determined to be appropriate for the site, restore natural in-stream channel conditions, dimensions, and patterns on streams that have been impacted by roads or high use. ▪Construct preventative controls to protect the Tern Lake Day Use Area from impacts associated with Upper Daves Creek, while maintaining the natural character of the stream.	▪A watershed restoration plan for the Quartz Creek Watershed may be needed to fully evaluate potential stream restoration opportunities. This plan would evaluate channel processes in detail, determine suitable reference parameters, and set a strategy for accomplishing the work. ▪An inventory of mining operations in the watershed is needed, as well as an inventory of the impacts of placer mining operations to stream channels in the watershed. A GIS-based dataset would help Forest Service specialists identify and track these impacts. ▪An inventory of bank impacts along Quartz Creek is needed to address bank restoration needs. A re-survey of channel cross sections established in 2002 is needed to help determine the channel changes that are influencing bank erosion in this area.	▪Implement youth-based stewardship through partnerships with organizations such as the Youth Restoration Corps to accomplish bank restoration needs that require hand labor. ▪Stream bank restoration must occur only after the cause of the disturbance has been addressed. Trails, fences, and educational signs should be constructed prior to bank restoration to ensure that the restored area is not re-trampled. ▪Placer mining operations should be managed in such a way as to ensure that detrimental impacts to the stream banks and riparian vegetation are limited, within the context of the mining law. The Forest Service should work with miners to protect the resources. ▪Ensure that Forest Service projects comply with all applicable BMPs, as defined in the R10 Soil and Water Conservation Handbook (USDA Forest Service, Alaska Region 2006), to protect water quality.	▪Monitoring of stream channel morphology and riparian vegetation conditions in the Daves Creek Restoration project area is scheduled to occur in 2010, 2011, 2014, and 2017 at a minimum. ▪It would be beneficial to establish long-term gauging stations in the watershed to measure streamflow and water quality parameters such as temperature to better determine hydrologic changes that are occurring as a result of climate change. Key streams would be those that drain areas likely to experience the most change, such as the spruce-dominated valley floor of Quartz Creek. ▪High quality aerial photography should be collected periodically to evaluate changes that are occurring in the watershed. LIDAR elevation data can also be very useful for a variety of management and research needs related to water resources.
Vegetation and Ecology			
Desired future conditions for vegetation should be driven by the standards and guidelines listed in the Chugach National Forest Land and Resource Management Plan for each management area in the Quartz Creek Landscape Assessment area. This is generally vegetation that results from natural processes, but in the assessment area, treatments that enhance wildlife habitat may be performed (USDA Forest Service 2002). Desired vegetation conditions are those that best meet habitat requirements for production of desired wildlife.			

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
▪Work with wildlife biologists to determine desired species and structures that best meet the needs for wildlife management.	▪Vegetation in the area has been changing rapidly due to the spruce bark beetle epidemic. New maps showing current vegetation would be useful. No data exists for reference conditions.	▪In order to best manage the vegetation for wildlife in the Quartz Creek drainage, the Forest Service and other wildlife agencies should be consulted to determine the greatest habitat needs for wildlife species for which the vegetation is to be managed. Harvest should be done to maximize the use of natural and advanced regeneration (where regeneration is desired) and, when possible, to maximize wood products available to the public.	▪Monitoring for exotic insect pests should continue in cooperation with State and Private Forestry. ▪Continue monitoring spruce bark beetle activity. ▪Research on historical vegetation conditions is needed.
Botany and Weeds			
The abundance and distribution of sensitive plants will be stable.			
▪Development of a baseline of sensitive plant species in the project area prior to significant changes resulting from global climate changes.	▪Extensive inventories of sensitive plant habitat in the assessment area have not been conducted.	▪Survey for sensitive plant species as part of all project planning. ▪Develop mitigation measures for any project that will impact sensitive plant species . ▪Inventory areas potentially suitable for sensitive plant species outside planned project areas as schedules and funding allow.	▪Regularly monitor known sensitive plant sites for status and disturbance.
Exotic plant infestations will be decreasing in size. Undeveloped areas will be free of invasive species.			

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
▪Improve coordination with State and Federal agency partners, private groups, and volunteers to minimize the introduction and spread of nonnative plant species. ▪Educate Forest field staff and users about invasive plants and involve them in inventory, monitoring, and treatment.	▪Inventories have not been conducted in undeveloped areas. Infestations are expected to be very limited in undeveloped areas, but could occur in naturally disturbed sites such as those previously glaciated.	▪Develop management strategies based on the CNF Invasive Plant Management Plan (2005) and the Guide to Prevention Practices (USDA Forest Service 2001). ▪Emphasize prevention of spread of invasives into natural communities, and coordinate with the CNF treatment program based on priorities for control and eradication. ▪Inventoried naturally or anthropogenically disturbed areas of the backcountry periodically to detect infestations at early stages when they are susceptible to treatment. More resources may need to be devoted to inventory and treatment of nonnative plants as populations increase in size and distribution. ▪Aggressive treatment of new and small infestations is the most effective and efficient method of reducing adverse effects of nonnative species.	▪Periodically monitor developed sites to track the establishment and spread of nonnative plant species. ▪Monitor a sample of undeveloped areas, natural communities, and areas affected by natural disturbance processes. ▪Monitor treated infestations for effectiveness and population changes.

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
Fire and Fuels			
The predominant conditions on the CNF will be those that result from natural processes. Conditions that result from active management or restoration will be present in selected locations (USDA Forest Service, Chugach National Forest 2002a; page 3-13).			
▪Apply fire regime condition class (FRCC) or other models to determine fire risk, fire return intervals, potential fire spread, and strategies to deal with fire in the watershed. Future options for the planning area should include a fire use program within the limited suppression boundary. This will allow natural fire to play a role in shaping the ecosystem while reducing impacts and costs associated with fire suppression activities. Fire prevention signs at trail heads and road side stops could raise awareness of fire danger with the public.	▪Fire regime condition class (FRCC) mapping of the project area to ascertain departures from historic levels do not exist. Fuel characteristic classification system (FCCS) mapping for the project area to determine the rate of spread and severity of fire within the project area does not exist. ▪Stand data for input into fire behavior models and future treatment areas near highways and homes do not exist. ▪Current digital elevation models and 1-meter digital color orthoquads are needed for future limited fire suppression strategies or wildland fire use for resource benefit planning. ▪Accurate weather observations and patterns are needed within the Quartz Creek Watershed to manage fire under appropriate fire suppression strategies.	▪Restoration activities, such as prescribed fire and mechanical treatments, in these areas and small-scale forest management activities along the road corridors will create opportunities for the utilization of forest products. ▪Prescribed fires could occur on a limited basis each year for fuel reduction, improvement of wildlife habitat, and restoration to desired vegetative conditions, provided appropriate funding can be obtained. Catastrophic wildland fires are projected to be infrequent and, when they occur, will most likely be within major travel corridors and other centers of human activity. Smoke levels will be within State standards for particulate material, except when catastrophic fires occur (USDA Forest Service, Chugach National Forest 2002a, page 3-15).	▪Monitor the effects of increased use and fire occurrence within the watershed.

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
Aquatic Species and Habitats			
Maximize aquatic invertebrate and vertebrate production within the Quartz Creek Watershed.			
▪Protect and maintain the existing high quality aquatic and riparian habitats and restore and rehabilitate marginal and degraded habitat within the watershed. Provide public users of the watershed with educational information on their role in the protection of aquatic resources such as invasive species, bank trampling, fish identification, fishing regulations, and volunteer opportunities.	▪Fish and aquatic species distribution within the watershed. ▪Wetland, beaver pond, side-channel fish passage surveys and assessment.	▪Conduct a comprehensive reach-specific fish distribution and rehabilitation assessment of tributaries, wetland complexes, and lakes. ▪Complete a restoration plan of the streams, wetland complexes, and lakes to identify and prioritize site-specific projects. The rehabilitation plan should: (a) determine fish distribution for each tributary and identify introduced and/or invasive invertebrate and/or fish populations; (b) identify areas of high quality overwintering, spawning, and rearing habitats; (c) assess fish passage and access to existing overwintering habitat such as wetland complexes, beaver ponds, side channels and lakes; (d) assess high angler use access areas for bank trampling/bank instability; (e) identify degraded riparian areas including noxious weeds and introduced plant species; (f) assess the historic stream channel, road, and trail networks to identify areas where side channels and off channel habitat could be reconnected with their parent streams; (g) identify and prioritize reaches of stream that lack large woody debris, stream channel complexity, and hiding cover for fish; and (h) identify and prioritize areas for rehabilitation that have been degraded by mining activities. ▪Develop an aquatic education plan for the Quartz Creek Watershed which would include constructing kiosk at high use areas and campgrounds.	▪How many Dolly Varden and rainbow trout are harvested in Quartz and Daves Creek? ▪What is the population status of adfluvial Dolly Varden and rainbow trout within Quartz and Daves Creek? ▪What invasive species occur within the watershed, e.g., Atlantic salmon, northern pike, New Zealand mud snails? Where are the specific bank trampling locations and bank erosion rates? ▪How many recreational miners utilize the Quartz Creek Watershed and what are their impacts on aquatic habitat? ▪What impacts do commercial sport fishing guides have on fisheries, riparian habitat, and stream banks? ▪What percentage of the Quartz Creek Watersheds sockeye, coho, and Chinook are intercepted in the commercial, sport, and subsistence fisheries?

<table>
<tr><th>Opportunities</th><th>Data Gaps</th><th>Management Strategies</th><th>Monitoring and Research Needs</th></tr>
<tr><td colspan="4">Terrestrial Species and Habitats</td></tr>
<tr><td colspan="4">Bear/ human interactions are minimal, and the potential for wildlife habituation of bears is low throughout the watershed, but particularly in the brown bear core area.
Brown bear movement corridors are functioning, particularly into and out of the brown bear core area.
Disturbance to wildlife from aircraft and other recreation activities is minimal or within an acceptable range.
Wildlife populations are healthy and support a variety of uses including subsistence and sport hunting, watching wildlife, conservation, and other values.
A diversity of vegetation types and structures exists to provide a wide range of habitats for wildlife.
<table>
<tr><th></th><th>Mature/Old Growth</th><th>Pole and Young Saw Timber</th><th>Seedling/Saplings</th></tr>
<tr><td>Conifers</td><td>60%</td><td>20%</td><td>20%</td></tr>
<tr><td>Hardwoods</td><td>20%</td><td>20%</td><td>60%</td></tr>
</table>
Early-seral hardwoods exist away (1/4 mile) from the highway, and within moose winter range.
The risk of loss of late-seral conifer habitat due to fire is minimal.</td></tr>
<tr><td>■Actively manage habitat within the Brown Bear Core Management Area to meet the population objectives for brown bears and reduce dangerous encounters between humans and bears.
■Monitor current recreation use to determine current use, trends, and acceptable limits within the brown bear core area.
■Monitor current aircraft (flight seeing and floatplanes) use in the watershed, and identify potential disturbance to wildlife.
■Develop projects that enhance habitat in a way that decreases or does not increase moose collisions in the highway corridor.
■Enhance current vegetation and structure by increasing early-seral stages of hardwoods and conifers, while enhancing moose browse and cover for a variety of mammals and birds.
■Reduce fuels in high-risk areas for wildfire.</td><td>■Verify or identify brown bear population size and structure, spring foraging habitat for sows with cubs, summer feeding habitat, and winter denning habitat.
■Impacts that floatplanes and other flight seeing activities are having on wildlife, particularly sheep and goats is unknown.
■The impacts of the spruce bark beetle on habitat and wildlife such as goshawks are not known.
■Current recreation use in the brown bear core area, and level and trends of bear/human interactions.</td><td>■Increases bear awareness with interpretation and education. Provide additional bear-proof food lockers in backcountry areas.
■Improve visibility for bears near seasonal brown bear concentration areas such as the Carter-Crescent Trail and Devils Pass Trail.
■Design habitat management projects in the brown bear core to enhance brown bear feeding areas and reduce dangerous encounters between bears and humans.
■Increase early-seral hardwoods by 54% and early-seral conifers by 18%, by implementing patch cuts of varying sizes and shapes in mid-seral and late-seral stages. Promote hardwoods beyond ¼ mile of the Seward and Sterling Highways.
■Reduce fuels near trails and other human use areas to reduce fire risk to surrounding wildlife habitat.
■Develop a wildlife interpretive/education plan to promote responsible consumptive and non-consumptive use.
■Inventory and monitor existing MIS, TES,</td><td>■Monitor the effects of recreation activities and aircraft on wildlife in the watershed, particularly brown bears in the core area.</td></tr>
</table>

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
		and SSI species and habitats and potential impacts from recreational activities. ▪Increase awareness of potential impacts to outfitter/guides and flight instructors, and ask for voluntary compliance with recommendations. ▪Coordinate with the State of Alaska and ADOT to develop habitat treatments which enhance wildlife habitat away from transportation corridors to assist in reducing animal mortalities. ▪Look for opportunities to design projects that meet fuel reduction objectives concurrent with moose habitat enhancement. ▪Identify opportunities for mechanical and prescribed burn treatments to increase early-seral habitat for moose and other species. ▪Look for opportunities to promote mature and old growth habitats for northern goshawks and other species. ▪Reduce risk of fire in wildlife habitat by cooperating with hazardous fuel reduction efforts near state and private land.	
Heritage			
Greater coverage of the landscape assessment area by cultural resource surveys. More cultural sites evaluated for National Register eligibility.			
▪Project work (section 106), general research (section 110), monitoring (NFIM).	▪Less than 1% of landscape assessment area surveyed for cultural resources. Need information on where Forest users are focused to identify where negative effects to cultural resources are most likely to occur.	▪Forest Plan site management prescriptions.	▪Need greater survey coverage.
Recreation			

Opportunities	Data Gaps	Management Strategies	Monitoring and Research Needs
Management in accordance with Federal laws and the CNF revised Forest Plan. Non-motorize use will prevail during the summer use season (hiking, biking, camping, fishing, hunting, canoeing, rafting, etc.). Improvements that increase the ability of the area to accommodate additional visitors will occur as long as the natural quality of the area is not reduced. Improvements such as trailheads, parking lots, and new cabins may be constructed to permit longer winter recreation trips (USDA 2002a). Human uses and impacts are concentrated in appropriate areas per opportunity type and dispersed in appropriate areas, and social, biological and ecological impacts are within an acceptable range.			
▪There is potential for further development of recreational opportunities on Forest lands within the Quartz Creek Assessment Area. ▪Determine appropriate locations for recreational development where impacts have no adverse effects and/or can be easily mitigated. ▪The Crescent Creek area of the watershed is a brown bear core area management prescription and development of new facilities or trails in this area is not recommended.	▪Accurate and complete current public use figures, including types of activities on trails and the number and type of people displaced from full campgrounds or cabins. ▪Need to collect visitor use baseline data each year (type and level of use occurring by location).	▪Develop a plan to determine human use throughout the watershed, an acceptable range of use, and identify sufficient management actions when an unacceptable range is reached. ▪Rehabilitation and expansion of existing facilities (ongoing). Potential projects for revised Forest Plan implementation include trail reconstruction, cabin reconstruction (add, fix), campground toilet replacement, and riverbank restoration and revegetation. ▪Develop a management plan showing acceptable use for different areas and plan facilities in these areas. ▪Develop a data collection method to measure the increase in recreation impacts in the watershed on a social and biophysical level. ▪Separate conflict-prone user groups with different trail spurs on popular trail routes or increased educational/interpretive efforts. ▪To create a more positive visitor experience in some areas it may be reasonable to harden higher use areas, concentrate and disperse outfitter/guide use to appropriate areas to protect low use solitude experiences, and maximize non-density dependent experiences in higher use areas.	▪Monitoring of recreation use is vital to assuring a positive recreation experience for the diverse users of the Forest. ▪Monitoring of recreation use is vital to assuring impacts to resources are avoided or mitigated appropriately. ▪Monitoring of recreation cabin and campground users who could not access these opportunities due to the lack of vacancies is vital to gage and best meet future demand. ▪Monitoring trail construction for adherence to BMPs and soil quality standards. ▪Monitoring number and type of recreation use, as described in the decision documents for these projects, is vital to assuring biophysical impacts to resources and social impacts to visitors are managed or mitigated appropriately. ▪Monitor human uses in the watershed to maintain acceptable levels as identified in the Forest Plan.

8. Recommendations

Recommended Actions

These recommendations are specific actions that could be taken to implement the management strategies, take advantage of opportunities, or fill data gaps as listed in section 7.

Lands

At present, there are no lands-related recommendations. All public land orders and easements appear to be fulfilling the needs of the United States and other parties. In addition, there are no encroachment-related issues on the non-federally held lands within the landscape assessment area.

Geology, Minerals and Soils

Geology and Minerals

- Any proposals for locatable minerals receive a prompt response and proactive environmental analysis to allow reasonable, logically sequenced operations.
- Commercial requests for disposal of mineral material sales be contracted if private resources are not readily available and free-use requests permitted.

Soils

- Invasive weed species are a negative impact to soil quality and function, particularly soil biology and chemistry. The threat of invasives is growing because of increased population using the assessment area and because of climate change which is generally more favorable to weeds compared to native species. Aggressive preventative and treatment actions are recommended to maintain soil quality and species diversity. Reference the Chugach NF Invasive Plant Management Plan for appropriate management actions.
- Trails are an important capital investment and recreational resource in the assessment area. To protect the soil and land surface, trails need to be maintained properly. One of the most often overlooked trail maintenance actions is water bars. Historically, once eroded material backs up against or fills in behind the water bar, they have been cleaned. Rather than preventing erosion and stabilizing the tread, cleaning the water bars has the opposite effect of continuing erosion and destabilizing the trail surface. The recommendation is that water bars should stay in place and not be "cleaned". When a water bar is filled, a new water bar should be installed. Trail tread width and clearing width should be kept to the lowest minimum standard to serve the intended use. Single-track trails minimize erosion and weed invasion.

Trail relocation, and trail construction needs to be on the most appropriate land type and the most appropriate position on a given land type relative to location and grade to avoid unnecessary disturbance, erosion, and potential for weed spread.

- Vegetation treatment involving heavy equipment needs to follow the soil quality standards, although there are exceptions that can be made by the soil scientist; for example, on particular soils with histic surfaces and certain habitat types.

Vegetation treatment using prescribed fire generally has few harmful effects to soils with the exception of organic soils. Prescribed fires should not consume organics below the litter layer (Oi or Oe).

- Generally, when management actions are expected to disturb the soil, as much topsoil as possible should always be saved for finishing the project after disturbance. If topsoil is available, it should be spread and then covered with appropriate mulch, but generally not seeded or fertilized. There should be plenty of seed banks of native plants in the upper layers of topsoil to preclude the need for seeding. Fertilizing native topsoil can often substantially alter the habitat for native plants, which in turn can alter the composition and frequency of natives. Of course, there will be other occasions and situations where fertilizing will be appropriate and desirable. Topsoil should be handled and stored to maintain most of its original properties, including the soil biology and seed bank. There are specific techniques for example, to limit denitrification, and to best store topsoil depending on the kind of soil, season(s), and length of storage time. Contact the soil scientist when contemplating and designing projects.
- Most of the terrestrial carbon is below-ground. Manage soil and vegetation resources to maintain or increase the below-ground carbon sink and sequester the maximum carbon for long time-frames.
- Inventory landslide and landslide-prone areas using aerial photography, satellite imagery, and field-checking and mapping. Determine current and recent rates of movement by standard, published methods or adaptations of standard methods as appropriate. Store this data in NRIS, NASIS, or other appropriate Forest Service corporate database.
- Inventory land types and soils according to TEUI and NCSS standards. Store this data in NRIS and NASIS.
- Set up landslide mass-wasting monitoring if management finds a reason to track any existing or potential slope failure.
- Monitor vadose zone and wetlands associated with restoration for proper hydric soil classification and function.
- Most of the terrestrial carbon sink is below ground. Model the soil carbon pool as a baseline monitoring reference for climate change

Hydrology

The following recommendations apply to water resources concerns in the Quartz Creek Watershed, as related to the issues and key questions presented in this analysis.

- Continue post-implementation monitoring of the Daves Creek Stream Restoration Project, including channel morphology, vegetation, invasive plants, and aquatic species, as specified in the Daves Creek Watershed Restoration Plan (Bair et al. 2008).
- Construct recreational improvements at the Tern Lake Day Use Area to protect riparian growth along the banks of Tern Lake and Daves Creek, including replacement of the fish viewing platform and installation of a fence between the bridge and the fish viewing platform.
- Develop a watershed restoration plan for Quartz Creek, focusing on potential restoration activities along the lower 0.5 miles of Quartz Creek. This plan would include detailed morphology and fish habitat surveys and integrate with the recreation program for ways to deal with bank trampling and erosion issues. This would also include a study on

channel change in lower Quartz Creek, the effects of the road on channel dynamics, and a determination of what type of restoration, if any, might be applicable.

- If it becomes necessary and if practical, take measures to prevent Upper Daves Creek from migrating out of its existing channel and into a new path down the alluvial fan. Although this would be considered a natural process, preventative measures would protect Forest Service investments such as the Tern Lake Day Use Area the Daves Creek Restoration Project and would maintain existing habitat and fish/wildlife viewing opportunities at Tern Lake and Daves Creek.
- Collect better information on the effects of mining operations in the watershed. Create a map showing all approved mining operations and develop an inventory of the effects of these operations on water resources. Administer these mining operations to ensure that they are following Forest Service regulations, best management practices, and State/Federal laws.
- During various projects, use established methods to reduce emissions of greenhouse gases that may contribute to climate change. Implement activities that would improve the ability of the Forest to sequester carbon and improve the resiliency of the Forest to the impacts of climate change.
- Develop a multi-watershed strategy for the Kenai Peninsula to collect baseline data that would be used to evaluate the effects of climate change on various resources, including streamflows and water quality.

Vegetation and Ecology

- Provide opportunities for firewood for the public. The upcoming Bean North project in the analysis area may generate firewood.
- Continue monitoring spruce bark beetle activity and salvage dead trees when possible.
- Continue to cooperate with State and Private Forestry to monitor for exotic pests, such as Asian gypsy moth.
- Harvest should be done to maximize the use of natural and advanced regeneration (where regeneration is desired) and, when possible, to maximize wood products available to the public.

Botany and Weeds

Sensitive Plant Species

- Survey for sensitive plant species in all areas proposed for management or development.
- Conduct sample inventories of areas that provide sensitive plant habitat and have not yet been surveyed. Collect data on sensitive plant species presence, abundance, and threats to known sites.

Invasive Plant Species

- Inventories of nonnative plant species in the Quartz Creek Landscape Area have been conducted mainly along roads and trails and in other developed areas, so there is little information about establishment of nonnatives in native ecosystems in this area. It is assumed that there are few nonnative occurrences in intact ecosystems, but current infestations of invasives may be expected to spread over time unless treated. Given the current low level of invasive plants in the assessment area, there is an opportunity to eradicate some invasive species and control others. Rapid identification and treatments of all new infestations in intact plant communities will be critical to maintaining the current pristine conditions of much of the area. Treatment of high priority species in developed areas is an important component of prevention of spread and control of current infestations. Many of the recommendations are from the integrated pest management plan (DeVelice et al. 2005).

Prevention

- Utilize the Guide to Noxious Weed Prevention Practices to prevent introduction and spread of invasive plants onto the Forest (USDA 2001).
- Evaluate invasive plant risk during project planning and plan projects to reduce risks.
- For all projects involving restoration, use natural revegetation where seed sources and site conditions are favorable to accomplishing goals. When conditions are not favorable for natural revegetation, use native seed/plant sources.
- All hay, straw, mulch, and forage should be weed free.
- Conduct treatments of invasives prior to project implementation where ground-disturbing activities are scheduled to occur in areas infested with invasive plants.
- Clean equipment prior to entering National Forest System land.
- Ensure machinery cleaning and native seed stock use provisions in all contracts are clear, understood, and enforced.
- Maintenance of existing recreation trails and construction of new trails should be done in a way that minimizes disturbance to topsoil, and removal of canopy vegetation to prevent conditions conducive to nonnative plant establishment.
- Gravel pits used as sources of construction materials should be free of weeds and/or treated prior to use.

Detection and Response

- Work internally and with partners to detect new invasive plant species infestations and to achieve containment or eradication of these infestations.
- Develop strategies to rapidly identify and control new infestations.

Control and Management

- Implement appropriate control and management strategies for priority for established infestations of invasive plants.
- Follow guidelines in the CNF Invasive Plant Management Plan (DeVelice et al. 2005).
- Survey for proposed, endangered, threatened, or sensitive plant species prior to treatment of invasive species and protect them from the impacts of treatments of invasives.
- Repeat treatments for several years in areas where invasive plant seed banks have developed.

Restore

- Restore areas where invasive plants have been removed as needed and according to guidelines in the integrated pest management plan.

Research

- Facilitate appropriate research and development activities to ensure invasive plant management programs are effective and science based. Implement the recommendations of research conducted on treatment methods for particular species.

Inventory and Monitoring

- Conduct invasive plant inventories of all proposed project sites to ensure that mitigation measures may be included in project planning.
- Each project leader conducting any form of inventory, such as stand exams or botanical inventories, should coordinate with the Forest or District invasive plant coordinator to determine if inventory procedures should provide for identifying invasive plants.
- Monitor any prescribed burn sites or areas burned by wildland fires because burned areas are particularly susceptible to invasion by nonnative plants.
- Periodically monitor developed and undeveloped sites for new establishment or spread of invasive plants.

Education

- Raise internal and public awareness about the threat of invasive plants and actions to minimize their impacts.
- Develop a training program to assist project-level personnel (especially field personnel) in invasive plant identification and implementation of the integrated pest management plan.
- Provide weed-free forage regulations information to the public.
- Inform and involve the public in the detection and treatment of invasive plants.

Fire and Fuels

Conduct fuels reduction treatments in beetle-infested stands in the Quartz Creek Landscape Analysis Area. Treatments to be considered include a combination of hand and mechanical treatments and prescribed fire applications to address existing and expected fuel loads to reduce the threat to wildland fire suppression personnel and the public and to reduce the potential impacts on the environment resulting from an unplanned ignition and large-fire event. Ideally, treatments are recommended to be implemented in coordination with other resource areas to maximize benefits while reducing the risk of severe fire impacts.

Aquatic Species and Habitats

Inventory

- Conduct a comprehensive reach-specific aquatic species distribution and a habitat restoration assessment of Quartz Creek, Lower Daves Creek, Crescent Creek, Dry Creek, Jerome Lake outlet channel, Johns Creek, Slate Creek, Devils Creek, and Henry's Creek.
- Complete a comprehensive restoration plan that identifies and prioritizes site-specific projects for the streams, wetland complexes, and lakes within the Quartz Creek Watershed.

Coordination

- Coordinate and work with ADF&G on their aquatic nuisance species plan which includes a strong public education component for the Kenai River and Quartz Creek Watersheds.

Monitoring

- Establish baseline monitoring stations for exotic/invasive aquatic species and monitor annually.
- Conduct annual surveys of adult rainbow and Dolly Varden and develop population estimates.
- Identify bank erosion locations and monitor bank erosion rates.
- Monitor recreational mining use and impacts.
- Monitor sockeye escapement above Tern Lake, and Chinook and coho escapement below Tern Lake within the Daves Creek restored reach.

Research

- Determine the sport harvest rates of rainbow trout and Dolly Varden by guided and non-guided anglers.
- Determine the smolt-to-adult survival rates for sockeye, coho and Chinook within the Quartz Creek Watershed.

Terrestrial Species and Habitats

- Manage habitat within the Brown Bear Core Management Area to meet the population objectives for brown bears and reduce dangerous encounters between humans and bears.
    - Develop a monitoring program with the recreation program that will identify current recreation use, and current levels and trends of bear/human interactions. Start with existing trail and cabin data to determine if information from these sources will be adequate. If not, develop a plan for gathering this information. The plan should identify threshold levels of interactions to trigger management action.
    - Identify areas along the Carter-Crescent Trail that might benefit by vegetation treatments that could improve visibility for brown bears. Consider data from the monitoring program mentioned above.
    - Monitor current aircraft use in the watershed to identify potential disturbance and cumulative effects to bears, mountain goats, and Dall sheep in the brown bear core area.
- Monitor mortality numbers and trends of moose, bear, and other species of interest on the Seward and Sterling Highways. Determine high wildlife crossing areas and consider management options to reduce mortalities, including working with DOT to propose wildlife crossing structures if needed. Higher vehicle collisions at mile 40 and 43 of the Seward Highway and between miles 40–42 of the Sterling Highway may indicate travel corridors or areas of habitat connectivity. Monitor state trooper mortality records and winter tracks. Identify attractants and potential mitigation measures at these sites.
- Promote vegetative diversity to meet desired conditions by promoting early-seral hardwoods and conifers, while maintaining current mature and old growth stands (see table 25). Promote early-seral hardwoods on 54 percent of hardwoods by primarily

conducting patch cuts in large hardwood stands (see table 25 and figure 29 [yellow stands]). Promote early-seral conifers on 18 percent of conifers by primarily working in pole-sized conifer stands (see table 25 and figure 29 [light green stands]). Consider releasing some advanced spruce regeneration in large hardwood stands by removing hardwood overstory (figure 29 [within yellow stands]). Maintain current large conifers and some large hardwoods to retain existing and potential goshawk nesting stands. Thin to open understory, reduce fuels and fire risk, or promote growth (figure 29 [red stands]).

Table 25. Desired treatments for habitat improvement

Hardwoods	Existing Acres	Existing Percent of Hardwoods	Desired Percent	Percent Change Needed	Change in Acres Needed
Seed/Sap Hardwoods	420	6	60	+54	+4,149
Pole Hardwoods	2,132	28	20	-8	-609
Large Hardwoods	5,063	66	20	-46	-3,540
Total	7,615				
Conifers	Acres	Percent of Conifers	Desired Percent	Percent Change	Change in Acres
Seed/Sap Conifers	146	2	20	+18	-1,744
Pole Conifers	3,617	39	20	-19	-1,744
Large Conifers	5,601	60	60	0	+17
Total	9,364				

Rationale for Treatment Recommendations (figure 29): Treatment shown in figure 29 balance the needs to meet desired conditions as stated above with spatial considerations of where current wildlife use is occurring. It promotes goshawk nesting habitat in large blocks around current nest areas and closer to highways to deter moose/vehicle collisions, particularly near mile 40. It promotes moose browse near winter range and areas of known use while maintaining cover near browse areas, reduces browse potential near highway crossing areas where higher mortality has occurred, and does not occur within ¼ mile of either highway. It promotes conifer regeneration near areas known to have higher use by lynx. Large cottonwoods are retained for bald eagle nest habitat.

- **Seedling/sapling hardwoods:** More are needed to provide hardwood browse for moose, and food and cover for a variety of birds and small mammals. There is an excess of pole size and large hardwoods compared to the desired condition. Some of these stands could be treated with patch cuts to generate early-seral stages. Work should occur in stands over ¼ mile from highways. Large cottonwoods should be maintained for bald eagle nest sites. Work could be done in aspen and birch stands, preferred browse species for moose.
- **Large Conifers:** Currently, we are meeting desired conditions for large conifers (60 percent). It is important to maintain the 60 percent and promote growth in other stands to meet the needs for future large trees.
    - It is important to maintain existing mature habitat for species like goshawks, Townsend's warblers, marbled murrelets, and other migratory birds. Habitat improvement can be done by reducing fuels where dead spruce is present. Opening the understory while maintaining the closed canopy in areas near

current goshawk territories can promote future nesting habitat and reduce ladder fuels. All potential nest habitat stands are shown in figure 26. Best treatment areas are shown in figure 26 (red stands).

  - *Promote future mature habitat:* Other stands that do not have dead trees may benefit from thinning to enhance growth or to open the understory. Stand structures such MH2, or pole-sized mountain hemlock have been used by goshawks at times for nesting and offer opportunities to enhance stands for future nesting habitat by promoting growth of larger trees. Most of the potential habitat is along roads, offering some access. Promoting goshawk habitat near roads meets other objectives to promote mature or large conifers or hardwoods rather than early-seral hardwoods near roads that could attract moose and promote moose/vehicle collisions. Best treatment areas are shown in figure 26 (dark green stands).

- Promote early-seral hardwoods for moose, lynx, and migratory birds. Promote hardwoods away from the highways to reduce vehicle collisions with moose, and preferably within or adjacent to moose winter range (see figure 29 ([yellow stands]). Cover stands (larger conifers) should be close by.

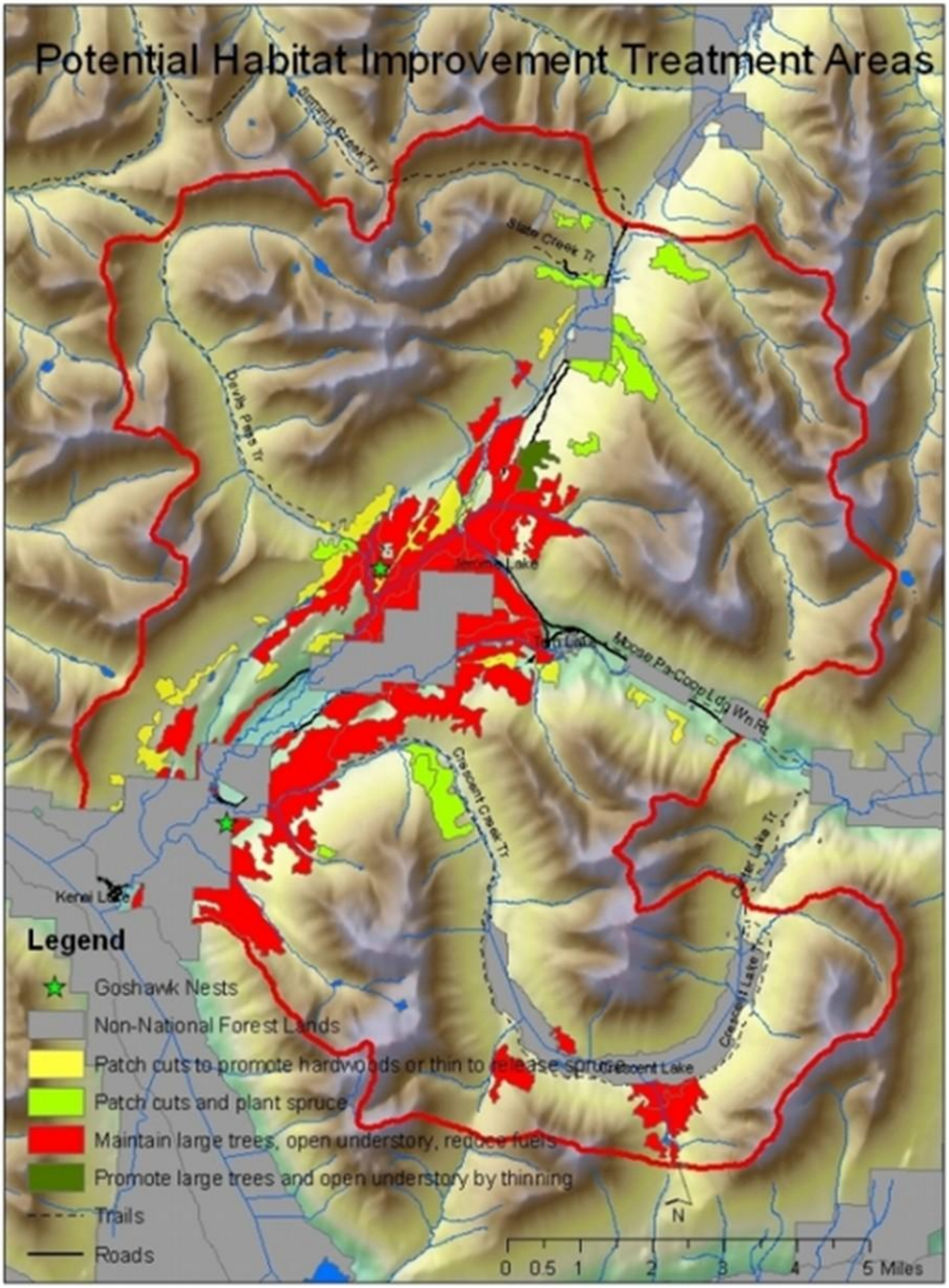

Figure 29. Potential wildlife habitat improvement treatment areas

Heritage

- Continue to carry out section 110 surveys outside of the valley bottoms where most project (section 106) work takes place.
- Establish priorities for assessing National Register eligibility of unevaluated properties in the landscape assessment area.

Heritage assessment relies upon data which covers less than 1 percent of the landscape assessment area, meaning that actual cultural resource distribution and significance across the landscape assessment area would be much greater than that defined in this report.

Recreation

- All facilities developed for recreational use need to provide access for people with disabilities. The Forest Service has developed guidelines that describe how to provide this access while also maintaining the setting as described by the ROS (recreational opportunity spectrum). Facilities need to be readily locatable by the public. Adequate sign plans and implementation of these plans is needed to ensure people can find the recreation opportunities we are providing. Internet information currently helps pre-trip planning and needs to be enhanced and maintained.
- *Crescent Creek Campground.* In general, demand for car-based camping is high on weekends, and often, during the weekdays, campgrounds are not fully occupied. Traveling by recreational vehicle (RV) continues to be popular through Alaska and the CNF. The Crescent Creek Campground was designed for car/tent campers and does not have generous parking spaces favored by RV campers. There are no dump stations or utility hookups for RVs in the Crescent Creek area. RVs need places to dump their waste and refill with fresh water as they travel. It is important to provide a diversity of opportunities to better serve our diverse public: providing a small, car/tent-based camping opportunity in the region is important, as other campgrounds nearby (Quartz Creek, Russian River) provide for larger RV-based camping and, therefore, the need for larger RV camping opportunities is potentially being met. It is likely that many of the users who prefer small tent-based camping have been displaced from these larger campgrounds.
- *Tern Lake Recreation Site.* There is much potential for improving Tern Lake Day Use Area. It is recommended that recreation staff add this site to their overall management planning efforts and budget discussions.
- *Roads Inventory.* A comprehensive inventory of all roads and travel corridors in the Quartz Creek Watershed is recommended. It may be beneficial to coordinate with those in other disciplines, such as vegetation managers, to secure funding for this type of project, as these inventories can be valuable for a myriad of resources.
- *Visitor Use Data.* A formal visitor use study is recommended for multi-use trails on the Seward Ranger District, including the Quartz Creek Watershed, to better understand public use and direct commercial users. The results of this type of study will inform management decisions on distribution of commercial users by activity type and location and will inform visitor management strategies designed to decrease use conflicts between commercial and public users and between various user groups.

It is important to note that the Crescent Creek area of the watershed is a Brown Bear Core Area management prescription and development of new facilities or trails in this area is not recommended. It is recommended that the trailhead register data in the watershed be compared to archival infrared trail counter data collected by special uses staff to verify the accuracy of trailhead register sign in percentages (recreation staff estimates that 33 percent of Forest users sign in at trail registers) and to create a more realistic understanding of actual use patterns/trends in the watershed.

- *Monitoring.* Monitoring all recreation use in the watershed is recommended. It will be important to monitor angling activity (utilizing biophysical and social indicators) along Quartz Creek and other nearby rivers receiving recreation pressure due to consumptive use and make improvements as needed. Maintaining a diversity of recreational opportunities and experiences in the watershed is recommended to better meet the needs of a diverse public, i.e., providing low use, solitude experiences such as Quartz Creek and high use angling opportunities such as Russian River.

Monitoring cabin and campground visitor use in the Quartz Creek Watershed is recommended with specific indicators and standards that when exceeded, prompt management discussion on whether existing recreation development is sufficiently meeting the recreation demand/needs of the public.

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Appendix A: Region 10 Sensitive Species

Species	Rank	Habitat	Occur-rence on CNF	Potential Habitat in QCLAA
Eschscholtz's little nightmare (*Aphragmus eschscholtzianus*)	G3S3	Tundra and heath, solifluction soils, scree/rocky ridges in alpine; usually in wet areas, along small streams, ponds in wet moss and rocky snow melt areas, wet cliffs, moist moss depressions	K	Yes
Moosewort fern (*Botrychium tunux*)	G2G3 S2S3	Open sand dunes, upper beaches, upper beach meadows with sandy substrates; in the mountains on sparsely vegetated alpine scree slopes	S	Yes
Spatulate moonwort fern (*Botrychium spathulatum*)	G3S1	Sandy upper beach meadows; also in alpine areas	S	Yes
Moonwort (*Botrychium yaaxudakeit*)	G2S2	Sandy beaches along the Yakutat Forelands	S	No
Edible thistle (*Cirsium edule var. macounii*)	G4S1	Moist to mesic meadows, open forests, open areas in higher elevations, and talus slopes	S	Yes
Sessileleaf scurvygrass (*Cochlearia sessilifolia*)	G1G2 Q S1S2	Low energy estuarine sites, in the intertidal zone, on gravel bars or spits, inundated at high tide	S	No
Spotted lady's slipper (*Cypripedium guttatum*)	G5S4	Open forests	K	Yes
Mountain lady's slipper (*Cypripedium montanum*)	G4S1	A variety of habitats including open forests and beach meadows	S	Yes
Large yellow lady's slipper (*Cypripedium parviflorum* var. *pubescens*)	G5T5 S2S3	Peatlands, often on limestone substrates	S	Limited
Calder's lovage (*Ligusticum calderi*)	G3G4 S1	Subalpine meadows, rocky cliffs, open boggy or rocky slopes, edges of conifer forest; on calcareous soils	S	Limited
Pale poppy (*Papaver alboroseum*)	G3G4 S3	Well-drained soils and rock outcrops; usually alpine including rocky tundra ridges and mountain summits and mesic to dry scree; also in lower areas near glacial moraines, in sand and gravel of outwash, along gravel bars of glacial rivers, and in river floodplains; sometimes in gravel along roads	K	Yes
Alaska rein orchid (*Piperia unalascensis*)	G5S2	Dry, open sites, under tall shrubs in riparian areas, mesic meadows, and drier areas in coniferous and mixed evergreen forests from low elevation to subalpine	S	Yes
Lesser round-leaved orchid (*Platanthera orbiculata*)	G5S2	Wet coniferous forests, low elevation forested wetlands, old growth hemlock forests, near open water or boggy areas	S	Yes
Kruckeberg's swordfern (*Polystichum kruckebergii*)	G4S1	Sheltered cracks in the dunite rock of ultramafic outcrops	S	No
Unalaska mist-maid (*Romanzoffia unalaschcensis*)	G3S3	Gravelly areas along streams, on ledges and crevices in rock outcrops, often along the coast	K	Yes

Henderson's checkermallow (*Sidalcea hendersonii*)	G3S1	Estuarine habitats at the ecotone of the estuary and forest	S	Limited
Dune tansy (*Tanacetum bipinnatum* ssp. *huronense*)	G5T4T5 S3?	Sand dunes and well-drained soils	S	Yes
Lichen, no common name (*Lobaria amplissima*)	Not ranked	Trunks and main branches of trees of old-growth beach fringe edges	S	No

Appendix B: Cover Classes and Information for Kenai Peninsula Borough Vegetation Mapping by Marvin Rude (2007)

Earth Cover Classes 1989 Thermatic Mapping Ducks Unlimited/Spatial Solutions, Inc.	**Kenai Forest Cover Classes** 1997-98 Color Infrared Photos Kenai Peninsula Bark Beetle Project	
Clear Water Turbid Water	Water –	W
Snow and Ice Barren/Sparcely Vegetated	Barren/Snow & Ice –	Bn
Closed Conifer >75% conifer & 60%+ cover	White Spruce -	Ws
Open Conifer >75% conifer & 25%-59% cover	Black Spruce -	Bs
	Sitka Spruce & Hemlock -	SH
	Mountain Hemlock -	Mh
	Dead Species – Precede with D	
Woodland Deciduous 10% - 24% cover	Cottonwood	C
Closed Deciduous >75% decid & 60%+ cover	Aspen	A
Open Deciduous >75% decid & 25% – 59% cover	Birch	B
Closed mixed – Less than 75% dominant, 60%+ cover	Mixed – White Spruce, Hardwood	WsHd
Open mixed – Less than 75% dominant, 25% - 59% cover	Black Spruce, Hardwood	BsHd
	Aspen & Birch	AB
	Hardwood and WSpruce	HdWs
Alder - > 80% alder	Alder	Ald
Alder/Willow Riparian >60% alder or willow	Willow	Wil
Willow > 80% willow	Other Shrubs	OS
Other Shrubs < 80% willow or alder		
Herbaceous/Graminoids - < 40% shrub & < 40% Herb&grass	Grass & Herbs	GH
	Marsh	Mrsh
Clouds	Nonforest – gravel pits, beach, agricultural, urban less than 10% stocked	NF
Cloud Shadows		
	Harvest Area	Hvst
	Harvest with remaining Hdwd	HvstHd

Size Class: seedling and saplings	1-5 in	1
Poles	5-9 in conifer	2
	5-11 in hrdwd	2
Large	9 in + conifer	3
	11 in + hrdwd	3

Stocking Percent: Woodland	10% - 24%	W
Open	25% - 59%	O
Closed	60% - 100%	C

Understory: Where significant and can be clearly seen on photos will be designated with a " / "
Example: DWs3O/Ws2 would be a dead overstory of large white spruce in an open stand with live white spruce unerstory.

Classification Key For Kenai Forest Cover Classes

The Alaska Vegetation Classification by L.A. Viereck, C.T. Dyrness, A.R. Batten and K.J. Wenzlick used as a guide.

I. Water--- --------(W)

II. Nonforest (< 10% stocked) ----------------(No Vegetation High Country)------ Barren/Snow/Ice (Bn)
-----------------(No Vegetation Low Country)--------------- Nonforest (NF)

III. Forest (10% or greater stocking with trees)

A. Dead Trees---Species, Size Class, and Stocking preceded with (D)

B. Live Trees— a.Conifer – White Spruce--(Ws) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Black Spruce-- (Bs) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Sitka Spruce/Hemlock-- (SH) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Mountain Hemlock-(Mh) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

b. Deciduous - Cottonwood ----(C) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Aspen----- (A) – Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Birch ------(B) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

c. Mixed Stands

White Spruce and Hardwoods - (WsHd)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Black Spruce and Hardwoods - (BsHd)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Aspen and Birch – (AB)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Hardwoods and White Spruce – (HdWs)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

e. Harvested Stands------------------(Hvst)

IV. Shrubs

A. Alder---(Ald)
B. Willow---(Wil)
C. Other Shrubs-----------------------------------(OS)

V. Grasses and Herbaceous-DRY------------------------(GH)
VI. Marsh- WET grasses and herbaceous------------(Mrsh)

Appendix C: Nonnative Plants

Nonnative Plants Known or Suspected in the Assessment Area

Table C-1. Nonnative plants known or suspected to occur in the Quartz Creek Landscape Assessment Area

Scientific name[1]	Common Name	Rank
Achillea millefolium[1]	Yarrow	NR[2]
Alopecurus geniculatus	Water foxtail	NR
Brassica napus	Field mustard	NR
Bromus tectorum	Cheatgrass	78
Capsella bursa-pastoris[1]	Shepherd's purse	40
Cerastium fontanum ssp. *vulgare*	Chickweed	36
Cerastium glomeratum	Sticky chickweed	36
Chenopodium album	Lambsquarters	37
Crepis tectorum	Narrowleaf hawksbeard	54
Dactylis glomerata	Orchard grass	53
Elymus repens	Quackgrass	59
Erysimum cheiranthoides	Wormseed wallflower	NR
Galeopsis bifida	Splitlip hempnettle	40
Hordeum jubatum[1]	Foxtail barley	63
Leucanthemum vulgare[1]	Ox-eye daisy	61
Linaria vulgaris[1]	Yellow toadflax	69
Lolium perenne	Perennial ryegrass	69
Matricaria discoidea[1]	Disc mayweed	32
Melilotus alba[1]	White sweetclover	81
Papaver nudicaule	Iceland poppy	NR
Phleum pratense[1]	Timothy	54
Plantago major[1]	Common plantain	44
Poa annua[1]	Annual bluegrass	46
Poa partensis[1]	Kentucky bluegrass	52
Polygonum aviculare	Prostrate knotweed	45
Potentilla norvegica	Norwegian cinquefoil	NR
Rumex crispus	Curly dock	48
Stellaria media	Common chickweed	42
Taraxacum officinale[1]	Dandelion	58
Trifolium hybridum[1]	Alsike clover	57
Trifolium pratense	Red clover	53
Trifolium repens[1]	White clover	59
Tripleurospermum inodorum (perforatum)	Scentless false mayweed	48
Turritis (Arabis) glabra	Tower rockcress	NR
Veronica serpyllifolia	Thymeleaf speedwell	NR
Species Suspected in the Quartz Creek Area		
Hieracium aurantiacum	Orange hawkweed	79
Phalaris arundinacea	Reed canarygrass	83
Vicia cracca	Bird vetch	73

[1] Mapped in CNF GIS layer.
[2] Not ranked.

Species in or Near the Chugach National Forest with Invasiveness Ranks $\geq$ 65

Bromus tectorum

Caragana arborescens

Centaurea biebersteinii

Circium arvense

Cytisus scoparius

*Hieracium aurantiacum**

Hieracium caespitosum

Impatiens gladulifera

*Linaria vulgaris**

*Melilotus alba**

Melilotus officinalis

*Phalaris arundinacea**

Prunus padus

Sonchus arvensis

*Vicia cracca**

*Species likely to occur in the Quartz Creek assessment area.